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INTERNATIONAL EDITION
MARCH 16, 1989

EDN®

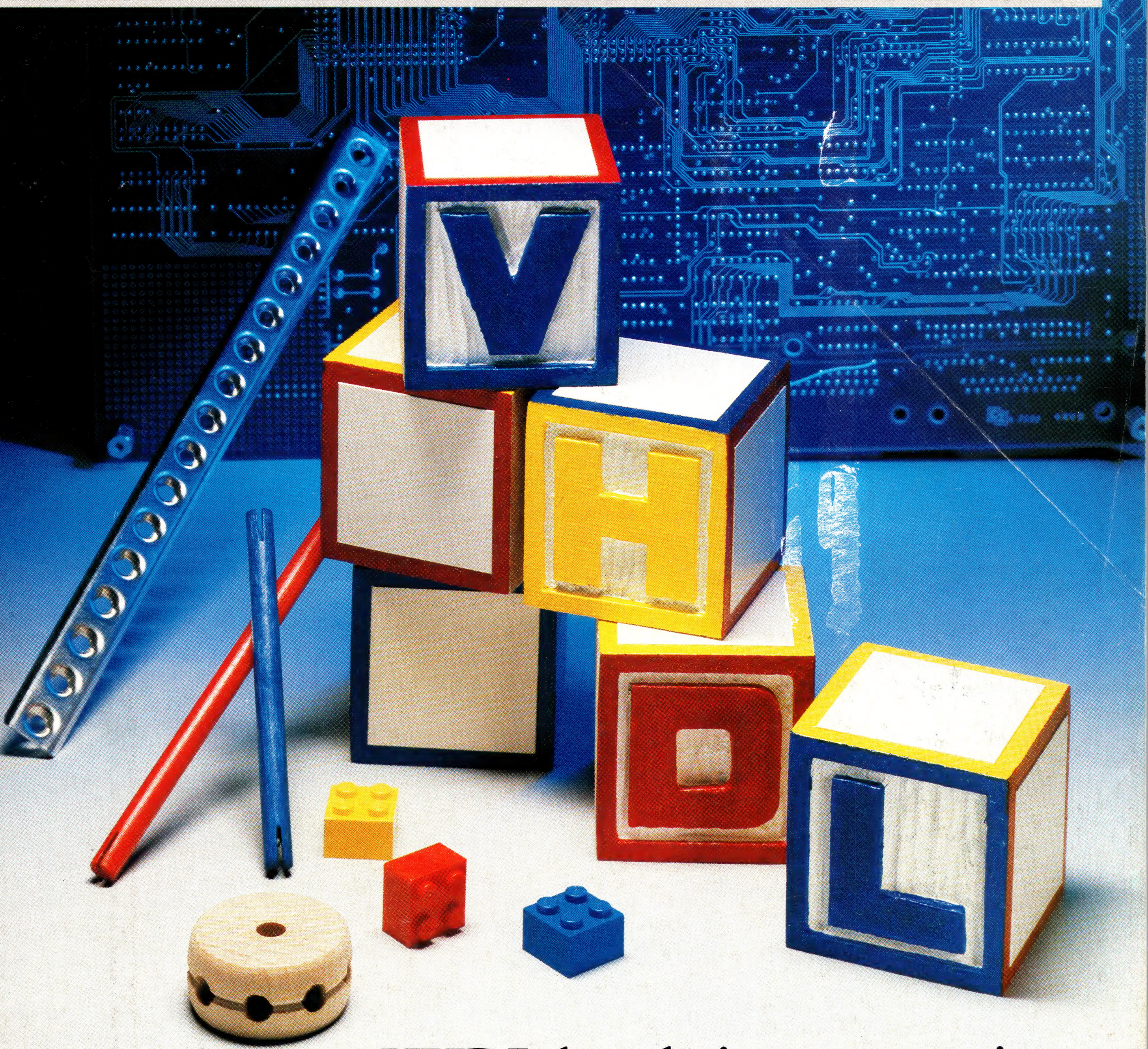
Bus-specific plug-in power sources

Improvements make smart cards smarter and faster

Fourier technique lets µPs synthesize waveforms

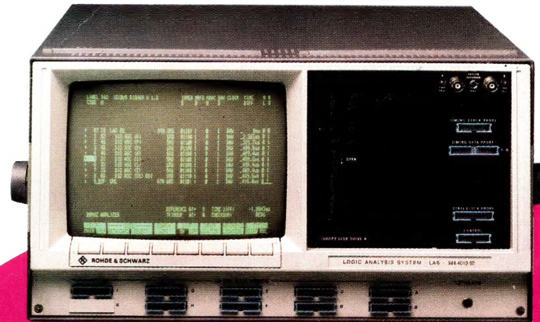
Electro preview

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS



VHDL lets design-automation tools play together

Modular Logic Analysis System



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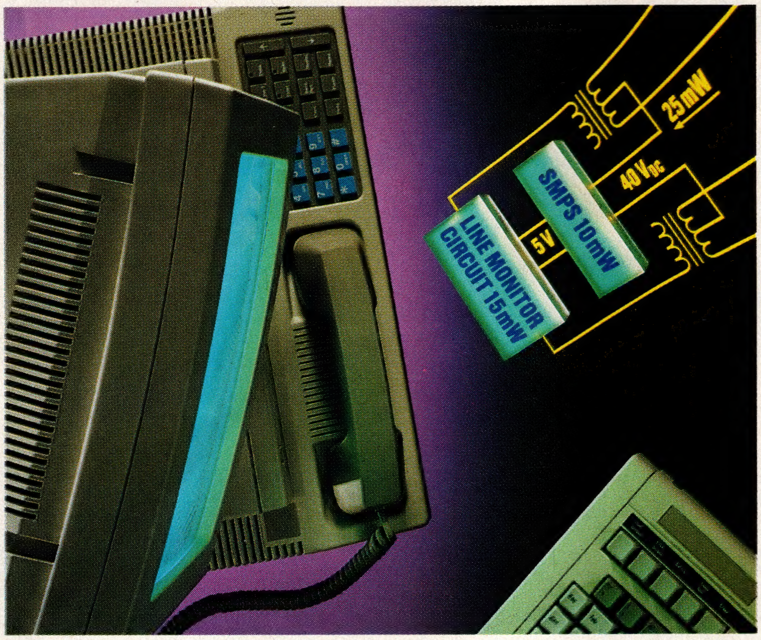

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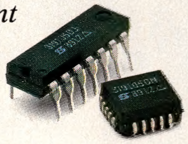

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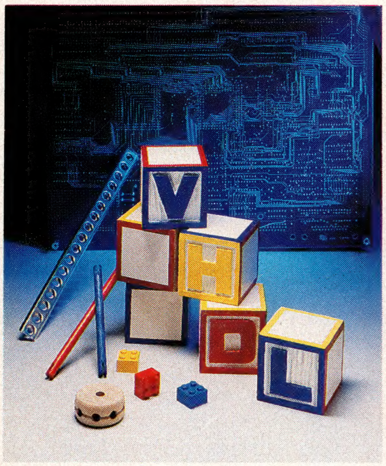
Volume 34, Number 6

March 16, 1989

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS



On the cover: *Because VHDL—the VHSIC (very-high-speed IC) Hardware Description Language lets you create system descriptions that you can simulate, you can verify a design before building a prototype or creating a detailed design. See pg 110. (Photo courtesy Intermetrics Inc; photography by Philip McElroy)*

SPECIAL REPORT

VHDL 110

The era of incompatible electronic-design-automation (EDA) tools is drawing to a welcome close. VHDL, the VHSIC Hardware Description Language, can concisely describe any digital electronic part, system, or subsystem using a single, standard dialect. And EDA-tool vendors are scrambling to make their products compatible with the language.—*Steven H Leibson, Regional Editor*

DESIGN FEATURES

Construct a low-cost 8096-family development system 131

Software engineers are often reluctant to abandon their familiar software-based debugging techniques. But when doing cross development, they often have no choice because the software they're developing won't run on the host system. Development hardware lets engineers extend their debugging expertise into the hardware domain.—*Eric P Horton, Dedicated Computer Systems*

Dynamic modes refine synchro-to-digital converter testing 149

More accurate testing of high-performance motion-control systems that use synchros or resolvers as position transducers and S/D converters is now possible. A look at various tests for an S/D converter shows how contemporary synchro simulators make testing easier as well.—*Franklin W Smith, Natel Engineering Co Inc*

Fourier technique lets µPs synthesize complex waveforms 163

Today's µPs are fast enough to generate a variety of waveforms by using Fourier synthesis. The helpful tips presented here can speed the run time of your subroutines and help you avoid some pitfalls when designing the hardware.—*Lee J Schugel, Schugel Engineering*

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BPA ABP

Continued from page 5

EDN Magazine Edition

March 16, 1989

***Miniature microcontroller and memory cards** are loaded with data, security, and processing capabilities (pg 69).*

EDN magazine now offers Express Request, a convenient way to retrieve product information by phone. See the Reader Service Card in the front for details on how to use this free service.

Express Request

TECHNOLOGY UPDATE

Smart cards are getting smarter and faster 69

Smart cards are now beginning to appear in an increasing number of applications, including electronic instrumentation, process control, diskless computers for harsh environments, and reconfigurable intelligent peripheral devices, such as printers and point-of-sale terminals.—*Chris Terry, Associate Editor*

Plug-in power sources simplify system design 77

Configuring a VME Bus system can be simplified by using plug-in power sources—units that slide directly into the system's card cage.—*Tom Ormond, Senior Editor*

Electro melds technical and personal concerns 88

The annual Electro show will include exhibits and demonstrations of computers, peripherals, software, instruments, testing equipment, fiber-optic devices, and components. And the line-up of professional sessions will give attendees up-to-date information on a large variety of topics.—*Joan Morrow, Assistant Managing Editor*

PRODUCT UPDATE

Data-acquisition and -display software 91

DESIGN IDEAS

Divider displays uncanny accuracy 179
Algorithm computes standard values 180
Program limits thermistor nonlinearity 182
Counter sequences aperiodically 184
Circuit cleans up noisy signals 186

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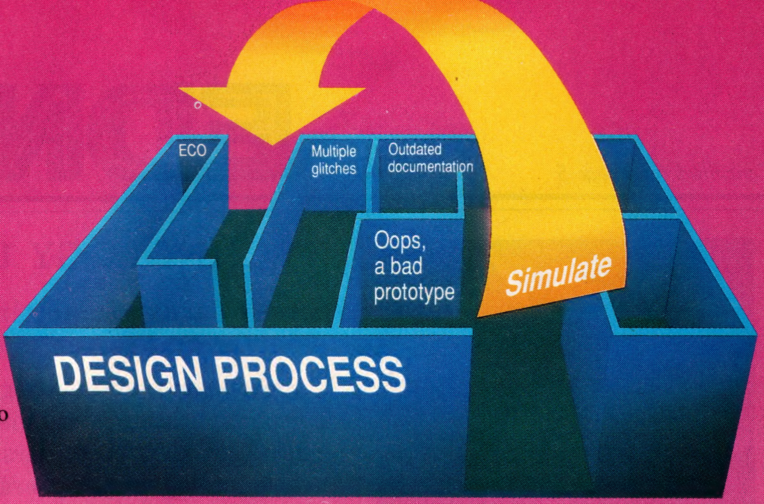
Cahners Publishing Company, A Division of Reed Publishing USA ☐ Specialized Business Magazines for Building & Construction ☐ Manufacturing ☐ Foodservice & Lodging ☐ Electronics & Computers ☐ Interior Design ☐ Printing ☐ Publishing ☐ Industrial Research & Technology ☐ Health Care ☐ and Entertainment. Specialized Consumer Magazines: ☐ American Baby ☐ and Modern Bride.

OrCAD Answers Your Questions About

Logic Simulation



Q: Why simulate?

A: To save time.

The ideal development cycle is schematic to prototype to production. Simulation dramatically decreases the dreaded loop of schematic to prototype to schematic to prototype to schematic to...

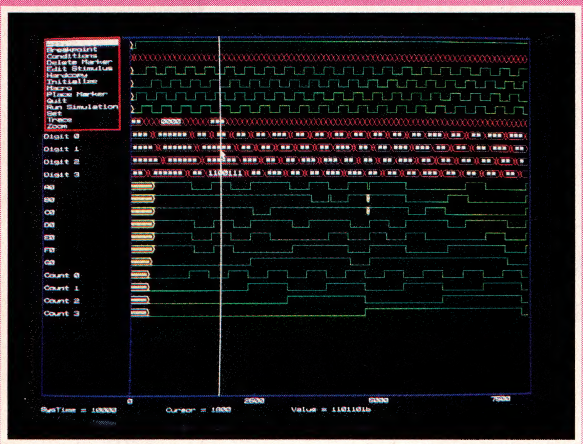
A: To save money.

If your design goes through several iterations, is the documentation still accurate? Suddenly your time and budget are being spent on laying in patches, not producing.

A: To make you look good.

Your schematic is supposed to be the best answer to someone else's design problem. Think of how great you'll look when you present a solution with no glitches, timing violations or other problems.

Verification of your design doesn't have to be handled at the prototype stage (or worse yet, the production stage).



OR8839I

You need a digital simulator that helps you find timing violations and design anomalies before you spend time and money on prototypes. The result: fewer iterations, a shorter design cycle, a more reliable product and getting the project right.

Why OrCAD/VST?

A: OrCAD/VST enables you to interactively verify your design as it develops. A netlist from OrCAD's powerful Schematic Design Tools is all that's required to get started.

A: OrCAD/VST features a user interface similar to OrCAD/SDT III, including easy-to-use menu driven commands and powerful keyboard macros. Your valuable time is spent designing and testing rather than trying to learn a new system.

A: OrCAD/MOD extends OrCAD/VST to PLDs. A set of PLD Simulation Modeling Tools, OrCAD/MOD produces models of PLDs for OrCAD/VST to use in simulation of the larger circuit in which the PLD will operate.

A: OrCAD/VST offers unsurpassed performance on a PC. Independent benchmark tests have hailed OrCAD's logic simulator as superior to other simulators costing 20 times as much.

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EDITORIAL 61

Forget about foreign competition—a lack of communication skills is what's killing many US companies.

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Power problems fuel sales of power-conditioning units . . . US manufacturing plants turn to FDC terminals.

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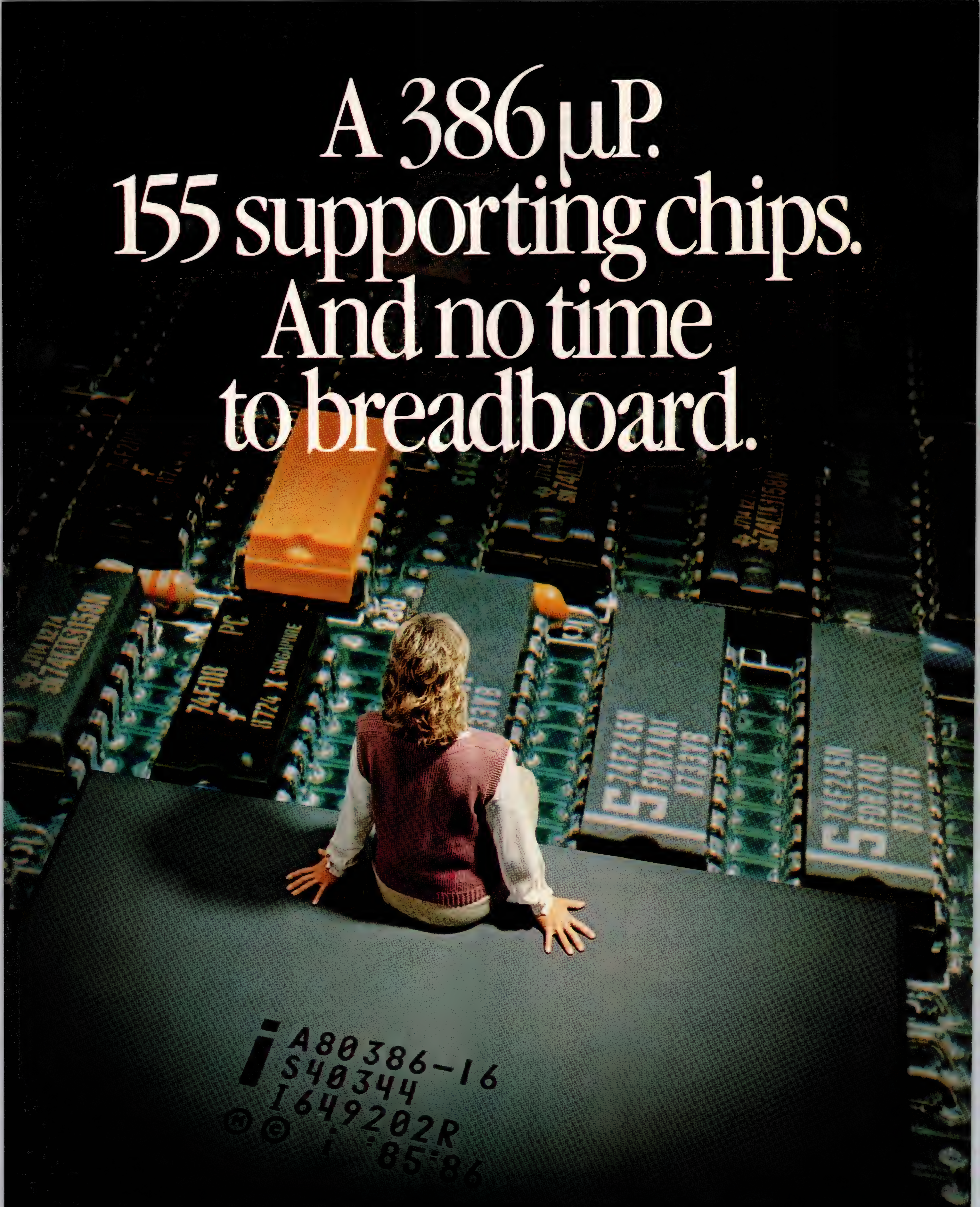
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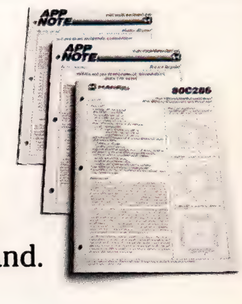

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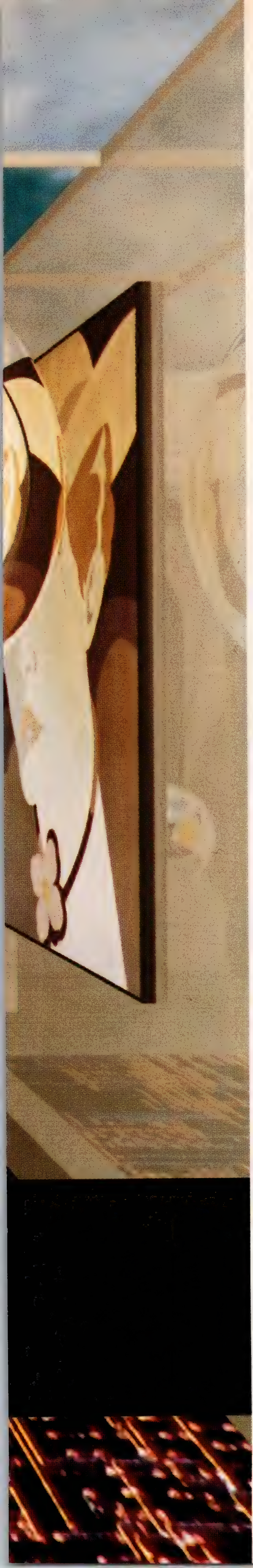

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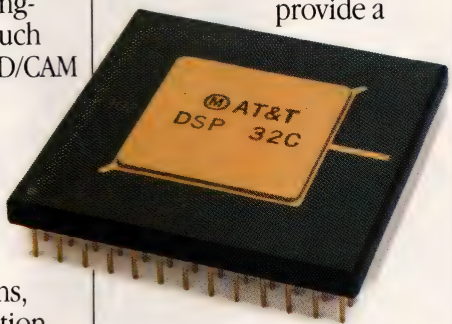

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Image created at R/Greenberg Associates on Pixel Machines' PXM 900 Series graphics workstation, using AT&T's first generation floating point DSPs.

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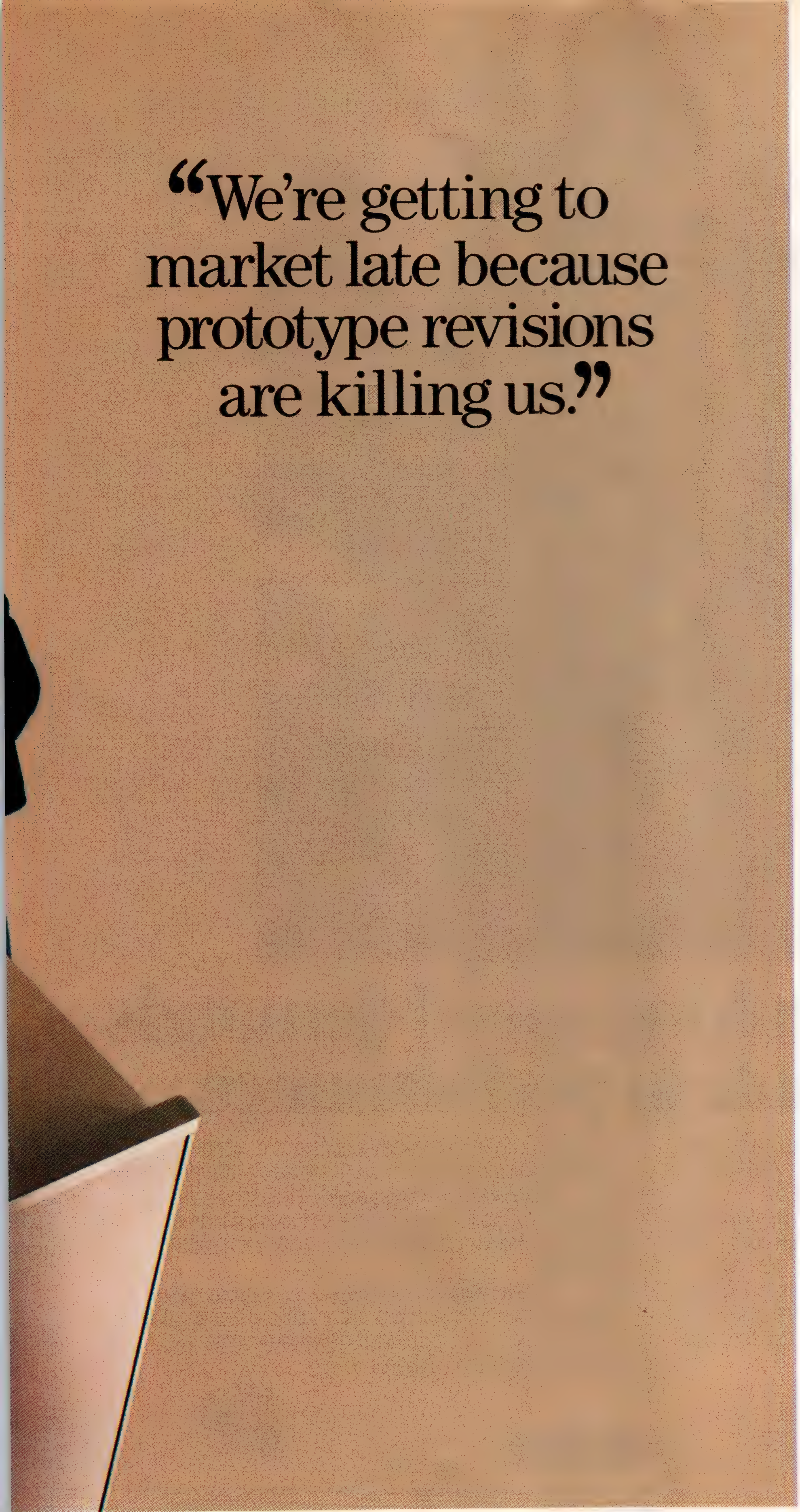

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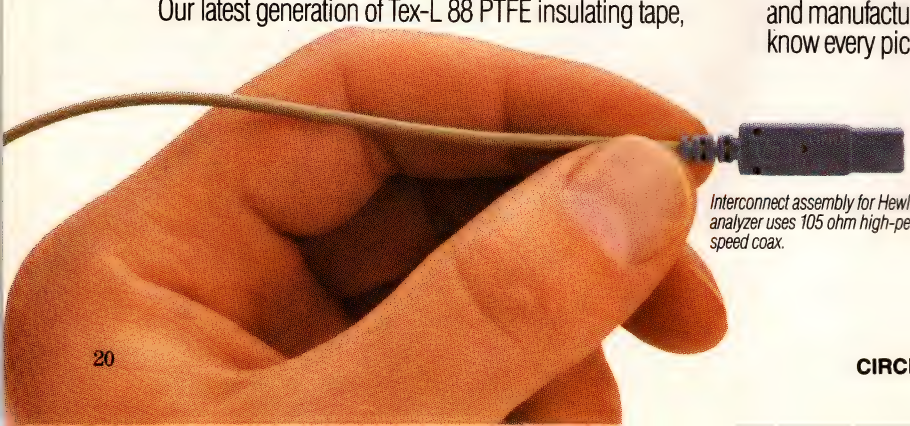

Interconnect assembly for Hewlett-Packard logic analyzer uses 105 ohm high-performance, high speed coax.

NEWS BREAKS

EDITED BY JOANNE DE OLIVEIRA

JUDGE RULES INTEL MICROCODE COPYRIGHTABLE BUT UNINFRINGED

On February 7, 1989, US District Court Judge William Gray filed his opinion in the case between Intel and NEC, in which Intel alleged that the microcode of NEC's V Series μPs infringed on the copyright of Intel's 8086 and 8088 processors. The judge's opinion states that microcode "consists of a series of instructions that tell a microprocessor which of its thousands of transistors to actuate in order to perform the tasks directed by the macroinstruction set," and therefore microcode is copyrightable because it fits the description of a computer program, which the US Congress added to the Copyright Act in 1980. However, wrote Gray, Intel forfeited its 8086/8088 microcode copyright by allowing some of its licensees to distribute several million 8086 and 8088 μPs without proper copyright notices. The judge also ruled that NEC's V Series microcode was not substantially similar to Intel's within the meaning of US copyright law.—Steven H Leibson

BUSCON/89 WEST EXHIBITORS INTRODUCE CPU AND I/O BOARDS

The Buscon/89 West trade show (held in February 1989 in Santa Clara, CA) served as a forum for the introduction of several board-level products that are compatible with open-bus architectures. Force Computers (Campbell, CA, (408) 370-6300), for example, demonstrated its VME Bus-based CPU-23 single-board computer. The board includes message-passing capabilities implemented by means of the Force FGA-002 VME Bus interface IC, and it targets real-time multiprocessing applications. The 68020-based board costs $4990 with a 12.5-MHz μP and $5990 with a 24-MHz μP.

Central Data (Champaign, IL, (217) 359-8010) showed a 20-MHz 80386-based Multibus II board that offers software compatibility with the Intel 386/120 CPU board. The Central Data board, Model CD22/1386, costs $6225 (100) and includes 4M bytes of dynamic RAM. The board employs a combination of fast-page-mode RAM ICs and an interleaved memory architecture to provide the deterministic performance required in real-time applications.

A RISC-based VME Bus product introduced by Motorola (Tempe, AZ, (800) 556-1234; in CA, (800) 441-2345) employs the company's 88000 CPU chip set. The product, Model MVME188, comes in versions having one to four 20-MHz 88100 CPU ICs, and ranges in price from $22,950 to $33,500 (100). Each version of the 3-board set includes 16M bytes of dynamic RAM and eight 88200 CMMU (cache/MMU) ICs.

In the I/O product area, Central Data and Ciprico (Plymouth, MN, (612) 559-2034) both announced SCSI host adapters. The Multibus II-based CD22/4550 from Central Data includes as much as 2M bytes of buffer RAM and costs $2255 (100) with 512k bytes of RAM installed. Firmware on the intelligent host adapter can implement an onboard cache and can employ a variety of disk-sorting algorithms. The VME Bus-based Rimfire 3550 from Ciprico offers compatibility with the new SCSI-2 specification. The $1695 board supports data-transfer widths of 8, 16, and 32 bits and offers a maximum transfer rate of 20M bytes/sec.—Maury Wright

PLASTIC, SURFACE-MOUNT IC PACKAGE SPORTS 524 LEADS

Because the number of I/O pads on advanced ASIC designs is continually increasing, vendors of custom chips have been hard-pressed to package the high-density silicon emerging from the diffusion furnaces in anything but exorbitantly expensive

and hard-to-test ceramic pin-grid arrays. To combat this problem, LSI Logic (Milpitas, CA, (408) 433-4104) has developed a family of eight plastic TQFP (tape quad flat-pack) surface-mount IC packages for its ASICs. The smallest TQFP has 164 leads on a 25-mil pitch, and the largest package sports 524 leads on a 10-mil pitch. Package body sizes range from 1.07 to 1.41 in. on a side. The company also offers these IC packages with an integral heat sink for high-power chips.—Steven H Leibson

DAISY OFFERS SABER ANALOG SIMULATOR FOR SUN 386i

Daisy Systems (Mountain View, CA, (415) 966-8300), which recently acquired Cadnetix (Boulder, CO, (303) 444-8075), will augment the marketing agreements that existed between Cadnetix and Analogy (Beaverton, OR, (503) 626-9700). According to the terms of the agreement, Cadnetix offered Analogy's Saber analog simulator for use on Sun-3 and Sun-4 workstations. Daisy will build on the agreement by offering Saber for the Sun 386i. Daisy's analog-simulation support package will include the translation of a 1400-component analog library into Saber format. —Michael C Markowitz

LOW-COST SMT DIRECTORY LISTS 1600 VENDORS

Bucking the custom of charging several hundred dollars for an SMT directory, the International Organization of Professional Advancement Conferences (IPAC, Los Gatos, CA, (408) 354-0700) is offering the 1989 edition of its *Desk Reference of Surface Mount Technology* for $45. The 128-pg book lists addresses, phone and FAX numbers, and contact names for 1600 SMT vendors. It's divided into 24 product categories. IPAC also publishes the monthly *SMT Nutshell News*, a free publication that addresses surface-mount issues, and manages the annual Expo SMT conference, which will be held this year from April 17 through 19 in Nashville, TN.—Steven H Leibson

DESIGN-VERIFICATION TOOL SUITS ASICs AND PLDs

The applications engineers of Altera Corp (Santa Clara, CA, (408) 984-2800) originally designed the Personal Logic Design Verification System (PLDVS) for their own use, but Altera is now offering the system to the rest of the world. The PLDVS allows designers to test TTL and CMOS ASICs and PLDs by using an IBM PC/AT as a workstation. The system comprises an add-in card for the computer, a device-test station that can accommodate as many as 128 pins, and system software. The software allows you to create test programs with a Pascal-like high-level language. The system costs $6595.—Richard A Quinnell

DOCUDRAMA SHOWS THE EFFECTS OF PRODUCT-LIABILITY LITIGATION

Any company that markets products is subject to the ravages of a product-liability lawsuit. *When Products Harm*, a docudrama produced by Commonwealth Films Inc (Boston, MA, (617) 262-5634), emphasizes concern for product-safety issues and alerts you to your legal exposure to a liability suit stemming from an accident caused by design or manufacturing defects. You can purchase the film in videocassette or 16-mm formats for $450 and $495, respectively; a 3-day rental costs $150. —Steven H Leibson

The Glitch is History

The Glitch won't disturb performance or raise the cost of your design again. Not if you specify TRW LSI's high speed 12-bit DAC. Because our TDC1012 is virtually glitch-free. It settles to $\pm 0.012\%$ of full-scale within 30ns. It operates at data rates to a guaranteed minimum of 20MHz, and reduces spurious harmonics to -65dBc or less, all without need of a sample-and-hold.

That's the finest harmonic distortion performance available, yet the TDC1012 is priced about the same as ordinary 12-bit DACs. But because it comes without the Glitch, your system cost will drop dramatically. Why? Because data registers are built-in. You won't need to add them or their potential for ground-loop noise. Nor will you need to de-skew data inputs with individually adjustable trimming capacitors. The peak glitch area is less than 25 pico-volt seconds, an order of magnitude less than other DACs. It will drive a 1V signal directly into a 50-ohm doubly terminated line (40mA full-scale), eliminating the need for an output amplifier. Without the need for trimming, de-glitching and these external components, you'll save time, too.

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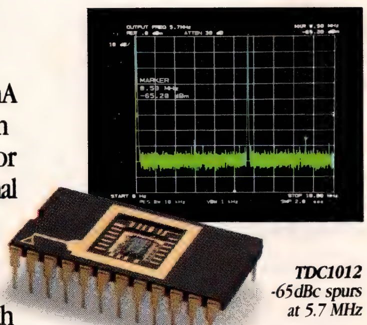

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CIRCLE NO 158

NEWS BREAKS: INTERNATIONAL

CHIP SET CUTS SIZE, POWER CONSUMPTION OF CELLULAR PHONES

Philips' Components Div (Eindhoven, The Netherlands, TLX 51573; in the US: Signetics Corp, Sunnyvale, CA, (408) 991-2000) claims that its new chip set can reduce a cellular phone's chip count by approximately 60%. Four of the six ICs are CMOS devices, so the chip set is suitable for use in battery-powered handsets. The UMA1000 chip performs computation-intensive tasks that are usually undertaken by the phone's microcontroller; for example, it performs filtering associated with the cellular phone's control, supervisory, and signaling data. The UMA1000 operates with either AMPS (advanced mobile phone service) or TACS (total access communication system) protocols. The bipolar NE5750 and the CMOS NE5751 control audio processing. The NE5750 performs companding, noise canceling, power amplification, and VOX control functions, and the CMOS NE5751 incorporates transmit and receive voiceband filters, a transmit lowpass filter and peak-deviation limiter, digitally controlled audio-path volume and muting functions, and a DTMF tone generator.

An NE605 FM IF mixer provides mixer/oscillator, IF amplifier, and demodulator functions, plus a received-signal-strength indicator and muting circuitry. A TDD1742 frequency-synthesizer IC provides frequency generation. An 80C552 microcontroller that communicates with the other ICs via an I^2C bus performs overall control of the phone set. Samples of the chip set are available now. Production volumes will be available in September 1989 at a volume price of less than $60.—Peter Harold

AGREEMENT WILL PROVIDE VRTX32 FOR MULTIBUS II BOARDS

Siemens AG (Ottobrunn, West Germany, (89) 4144-5945) and Ready Systems (Sunnyvale, CA, (408) 736-2600) have recently announced an agreement to provide VRTX32, Ready Systems' multitasking real-time kernel, for Siemens's OSM 80386-based Multibus II boards. Under the terms of the agreement, Ready Systems will integrate VRTX32, IFX (an I/O and file-management executive), TPX (a Multibus II transport protocol), and RTscope (a multitasking real-time debugger and VRTX32 system monitor) with Siemens's Multibus II boards.—Joanne De Oliveira

SMALLER NOVRAM WILL OFFER GREATER INTEGRITY

According to Japanese news reports, Sharp Corp has developed technology that reduces the size and increases the integrity of NOVRAMs. The company reportedly plans to develop a 256k-bit NOVRAM; trial manufacture of the device is scheduled for this spring. So far, the company has produced only the cell, which is 79 μm square and can maintain stable performance even when data is rewritten to it 100,000 times. To create the new cells, Sharp used dynamic RAMs instead of the static RAMs that have traditionally been used in NOVRAMs.—Joanne De Oliveira

HIGHLY CONDUCTIVE ALLOY IS SIX TIMES STRONGER THAN COPPER

Reports in the Japanese press say that Toshiba has developed a material having 90% of the electrical conductivity—and six times the strength—of copper. The material is an alloy of 97% copper and 3% aluminum oxide. It responds well to processing: The company claims the material can be shaped into a disc or cylinder having a maximum diameter of 40 cm. Toshiba plans to apply the material in Japan as early as this spring; it will begin delivering samples to outside markets in July.
—Joanne De Oliveira

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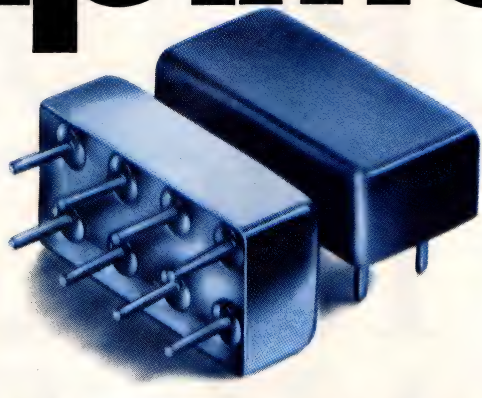
CIRCLE NO 159

rugged plug-in amplifiers



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another Mini-Circuits' price/performance breakthrough.

MODEL	FREQ. RANGE (MHz) f_L to f_u	GAIN dB min	flatness††	MAX. OUT/PWR† dBm	NF dB (typ)	DC PWR 12V, mA	PRICE $ ea. (10-24)
MAN-1	0.5-500	28	1.0	8	4.5	60	13.95
MAN-2	0.5-1000	19	1.5	7	6.0	85	15.95
MAN-1LN	0.5-500	28	1.0	8	2.8	60	15.95
◇MAN-1HLN	10-500	10	0.8	15	3.7	70	15.95
*MAN-1AD	5.500	16	0.5	6	7.2	85	24.95

††Midband $10f_L$ to $f_{u/2}$, ±0.5dB †ldB Gain Compression ◇Case Height 0.3 In.
Max input power (no damage) +15dBm; VSWR in/out 1.8:1 max.
*Active Directivity (difference between reverse and forward gain) 30 dB typ.

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CIRCLE NO 164

C118 REV. E

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When you think SMT for low-cost production, think of Mini-Circuits' low-cost SCM mixers.

SPECIFICATIONS (typical)	SCM-1L SCM-1NL (L=with leads)	SCM-2L SCM-2NL (NL=no leads)
FREQ. RANGE (MHz)		
LO,RF	1-500	10-1000
IF	DC-500	5-500
CONVERSION LOSS (dB)		
Midband	6.3 dB	6.5 dB
Total Range	7.5 dB	8.0 dB
ISOLATION (dB)	(L-R)(L-I)	(L-R)(L-I)
Low-Band	60 45	45 35
Mid-Band	45 40	35 30
High-Band	40 35	25 20
PRICE	$3.30 (1000 qty) $4.25 (1-9)	$4.15 (1000 qty) $5.45 (1-9)

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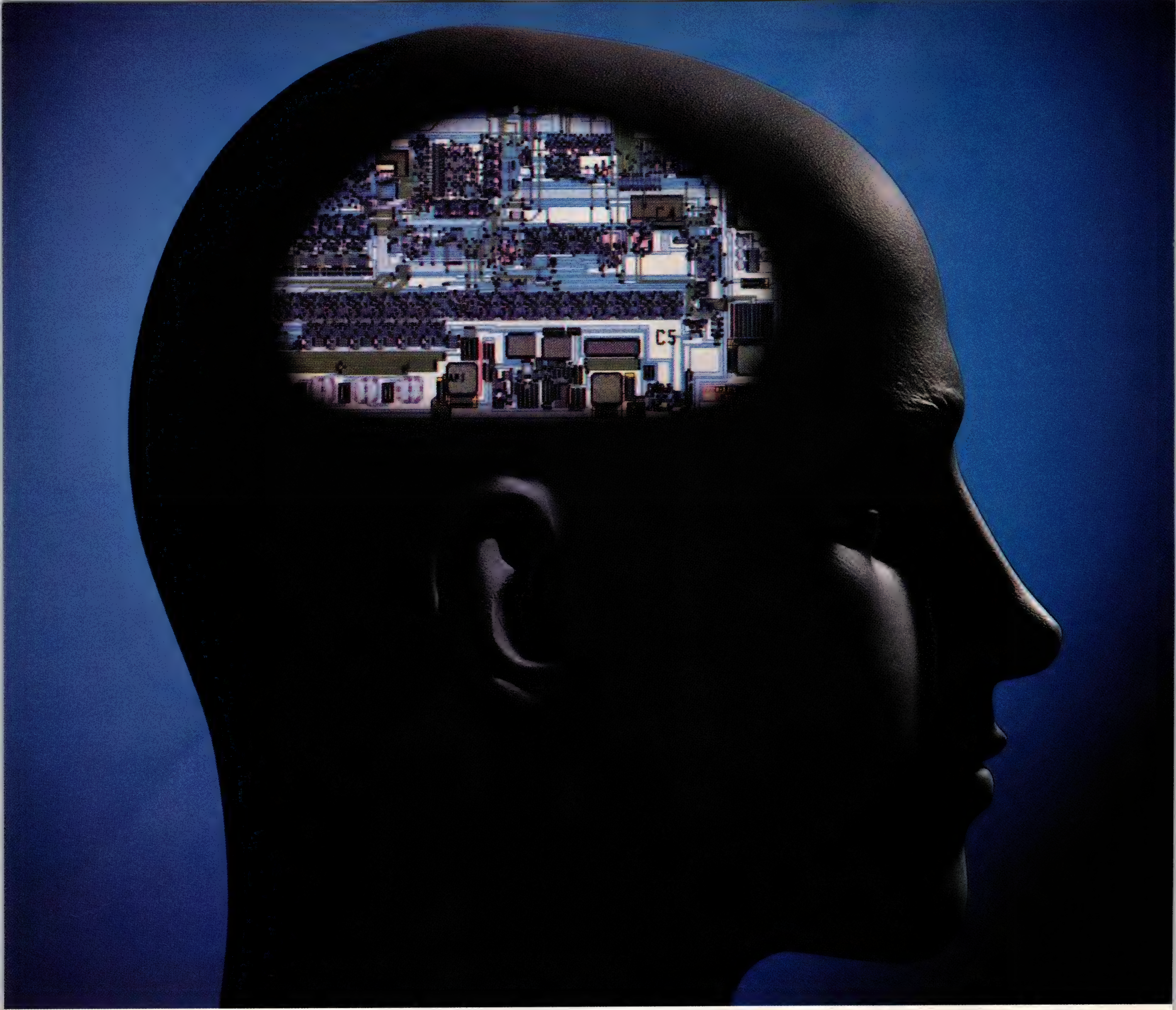
CIRCLE NO 165

C 115 REV. B



Anything this system can think of,

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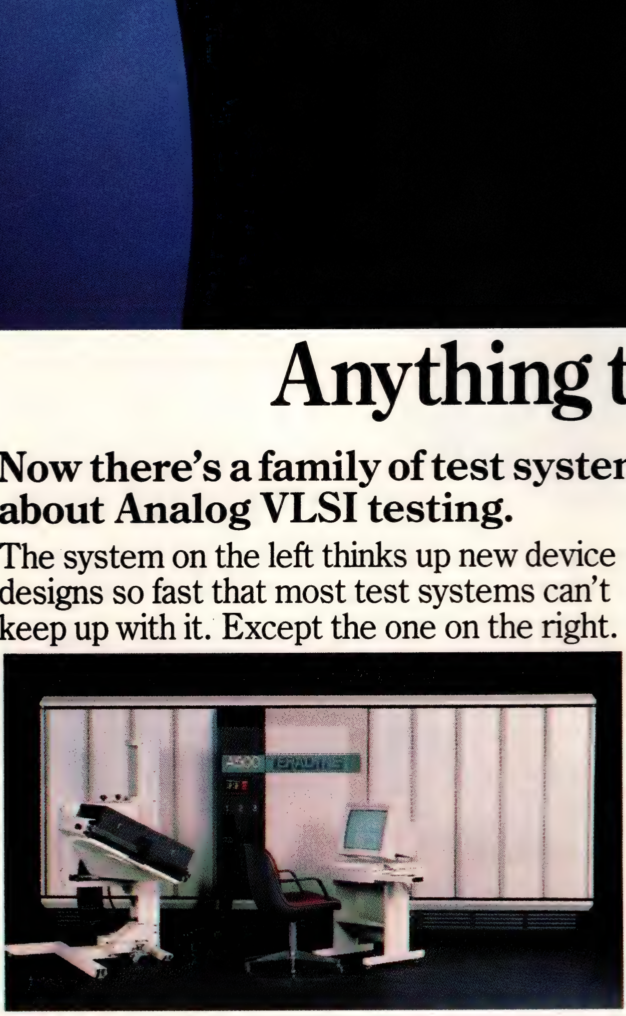

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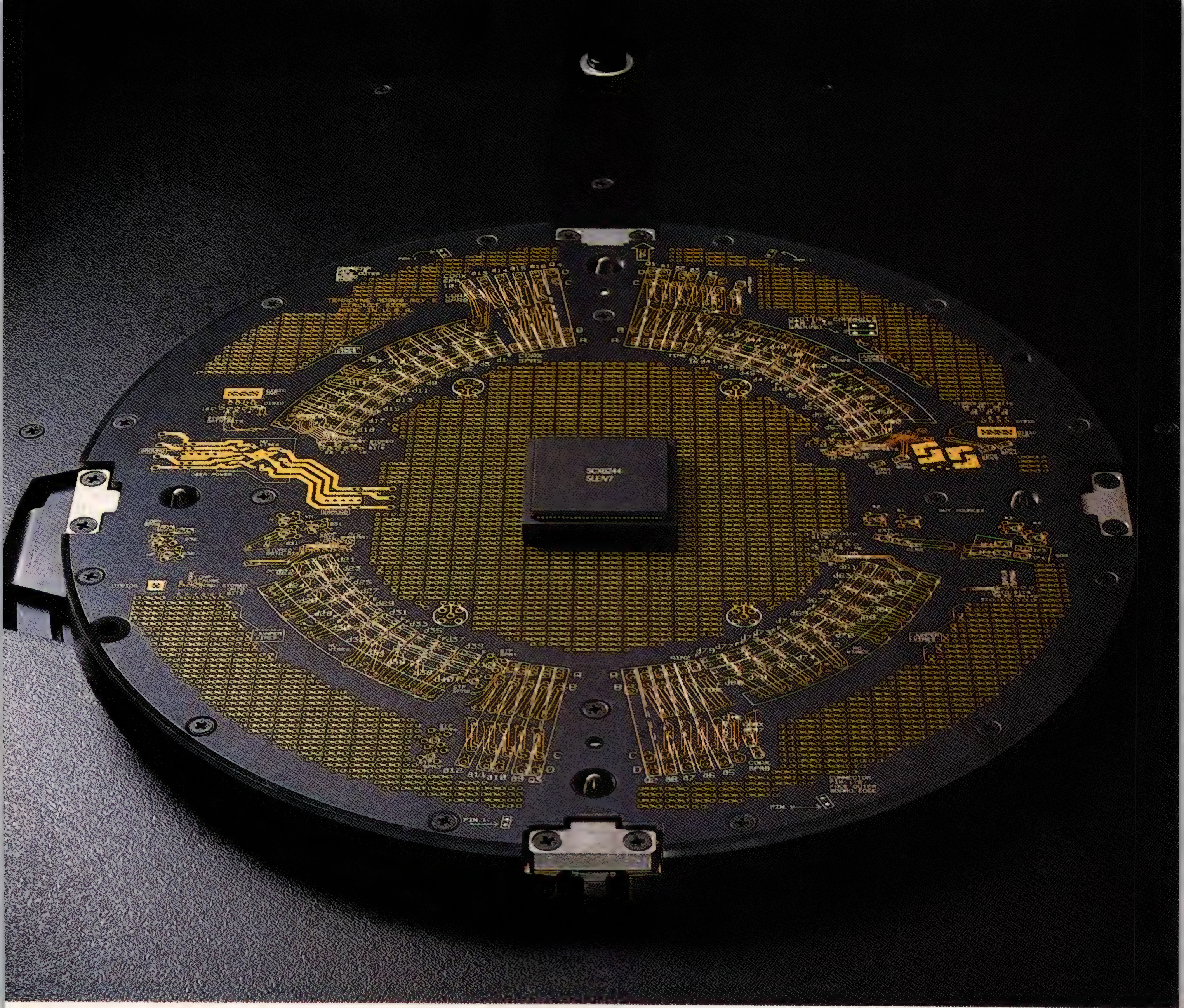

this system can test.

to test per test head, and the A520, which packs all the performance of an A500 into a smaller footprint at a lower capital cost.

Teradyne's new A500 family not only gives you the capability to test the range of today's devices, it's ready to help you test tomorrow's devices, as well.

The A500 family shares an architecture based on today's "open systems" standards—dual Sun computers, a UNIX operating system, powerful C-based IMAGE™ software and Ethernet TCP/IP networking. In addition, each system provides full tester simulation on stand-alone workstations, with graphic debug and analyzer tools as powerful as any CAD/CAE tools.

Spend your time testing designs instead of designing tests.

If you want to help your company bring next-generation products to market faster, prevent premature product rollouts and cut test engineering costs drastically, use the system on the left. Which can only lead you to the system on the right.

For more thoughtful details, call Beth Sulak at (617) 482-2700, ext. 2746. Or call your nearest Teradyne sales office or write: Teradyne, Inc., 321 Harrison Avenue, Boston, Massachusetts 02118.

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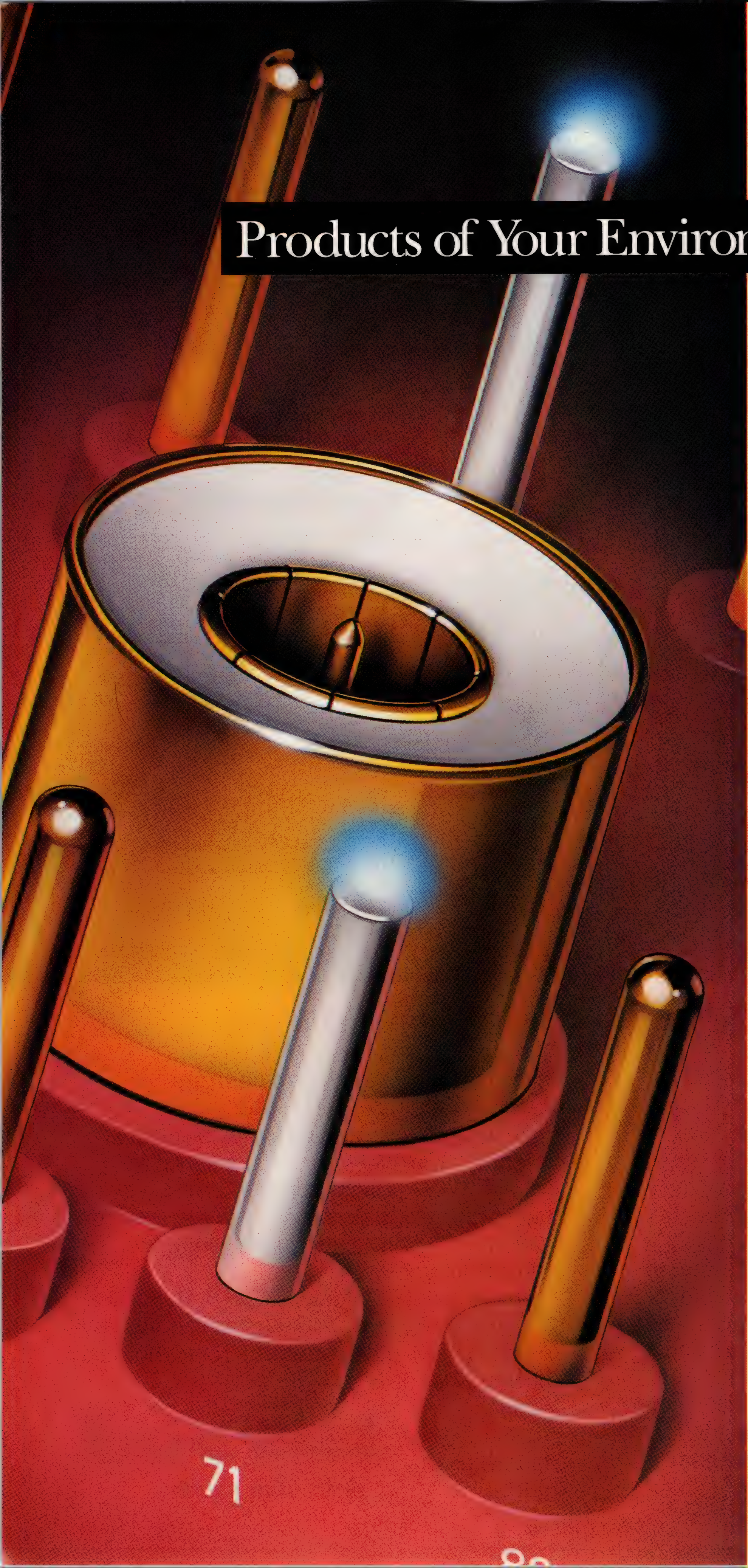

71

Start your own Algorithm Collection

In his letter of August 4, 1988, Alan Clark wondered where programmers find the algorithms needed to implement floating-point, transcendental, and sorting routines. The question is a valid one that's rarely addressed.

Algorithms are to the software engineer what logic devices are to the hardware designer. The programmer builds code around a number of mostly standard algorithms, much as a circuit designer connects off-the-shelf components in a unique configuration, creating something new from elements of the old.

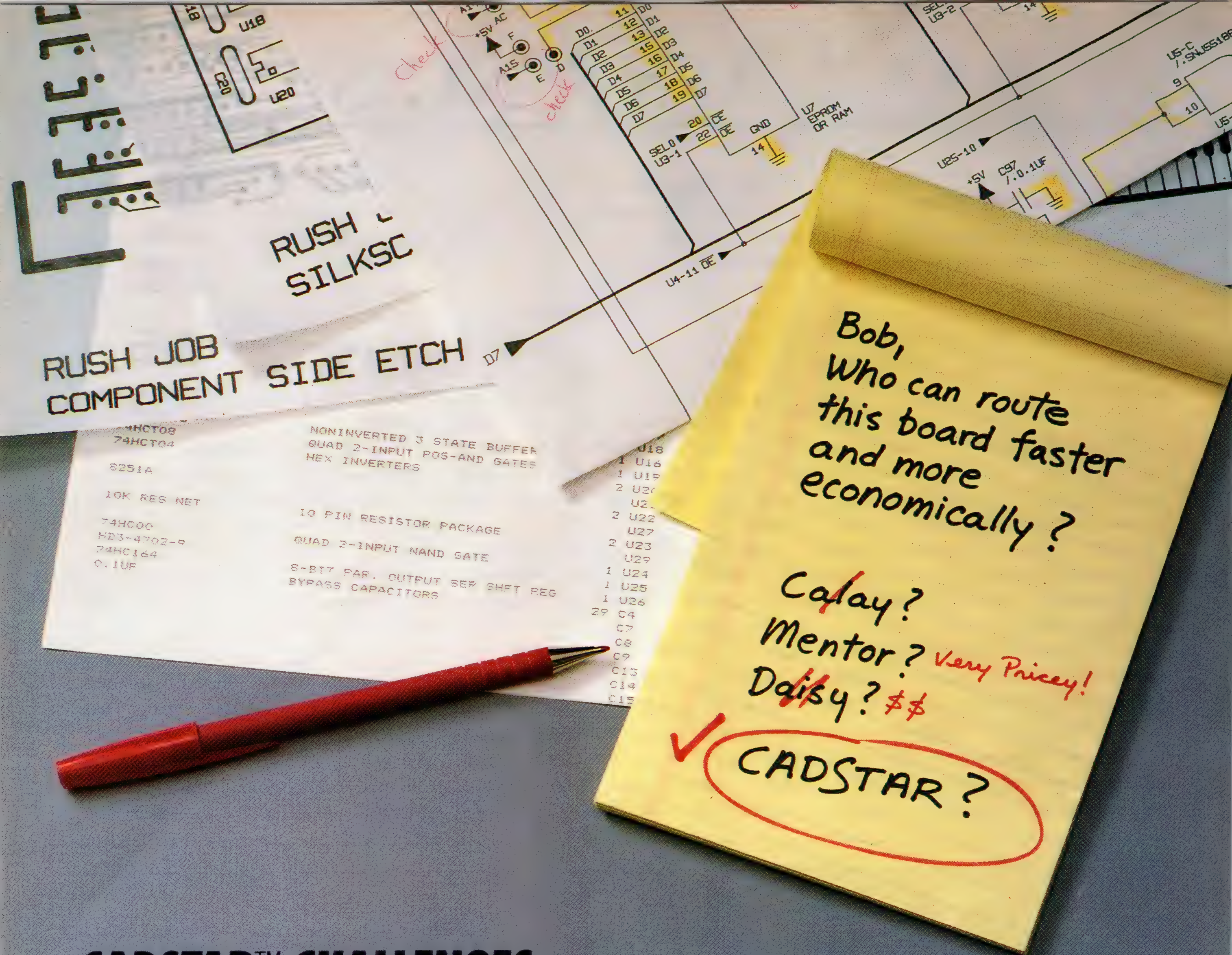
Algorithms are not the exclusive domain of software gurus. Circuit designers continually incorporate them in hardware. Multipliers and dividers can use simple shift and add techniques or complex schemes such as Booth's Algorithm, depending on the particular tradeoffs involved. State machines, especially ones using modern PLDs, use algorithms as complex as those found in real-time software.

Every engineer and programmer must actively collect all information that is or might be vital to producing products on time and on budget. When a crisis hits, there's no time to start trying to find a technique to solve a problem. All designers *must* build and maintain an Algorithm Collection.

The Collection can be as simple as a cardboard box with photocopied routines and techniques haphazardly thrown into it, or it can be a carefully sorted filing system. My Collection, started 15 years ago, is contained in a series of 3-ring notebooks. Each notebook covers a different subject, such as sorting, transcendental math, floating-point operations, Fourier transforms, etc. A shelf of carefully selected books containing a wealth of information complements the binders.

Over the years, I've spent no more than a total of 20 hours building and maintaining the Collection. That tiny investment has paid off literally hundreds of times, saving many man-years of effort in the process.

The average technical person is inundated with information, much of it trivial, much of it ignored, but much of it valuable. When you're sorting your mail or reading the trade journals, always stay alert for algorithms. Tear them out and add them to your Collection, even if they're not at all applicable to your current projects. Our profession changes completely every few years, and sometimes seemingly every few weeks. Tennyson's "The old order changeth, yielding place to new" is the only constant in the



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computer business.

The best sources of algorithms are magazines. About 20% of my Collection is from EDN. The earliest entries are some yellowing pages torn from EDN's 1972 issues. Other magazines, especially those dedicated to programming, can also be gold mines. Remember, sometimes good algorithms are disguised as circuits, code for obscure calculators, routines in Basic, or specific ways of solving generalized problems. It's important to read past article titles to see the method used to solve each problem. Typically, only the method, and not the problem, is of interest for the Collection.

Technical books are also a wonderful source. Compiler references, for example, contain many useful routines relating to languages. Look in unusual places: The *CRC Standard Math Tables* contain a wealth of information about series expansions, which are the basis of most transcendental calculations. This volume also contains other frequently forgotten basic trigonometric relationships that are essential to many computations.

The old standby for programmers is Knuth's 4-volume *The Art of Computer Programming* (Addison-Wesley Publishing Co, Reading, MA, 1969). Knuth's descriptions tend to be very mathematical and abstract, but they're useful.

Any book about numerical methods is invaluable. Particularly, Hamming's *Numerical Methods for Scientists and Engineers* explains all the basics of iterative calculations. *Digital Computation and Numerical Methods* by Southworth and Deeleeuw gives detailed flowcharts and sample code, albeit in Fortran, for many of these techniques.

Usually overlooked are technical manuals. For example, DEC's RSX-11M Fortran manual contains an excellent appendix detailing the approximations used in all of the library routines. Tandy's Basic manual for the ancient TRS-80 gives program listings for implementing most of the transcendental functions. HP's manuals for its line of calculators describe all kinds of calculations, covering many different fields of endeavor. The optional library for the HP-45 calculator was a particularly complete listing of algorithms for engineering and finance. I lost mine in a shipwreck in 1978, and I've sorely missed it ever since. In general, computers with limited abilities offer great descriptions of approaches to solving problems.

User groups are a traditional source of approaches to solving problems. Even better, user groups invariably supply listings of actual implementations of algorithms. Intel's Insite library for the 8008, and later the 8080, contained many hun-

dreds of generally simple, concise listings for virtually any engineering application. The 8008 needed all the help it could get! Its limited (although incredibly innovative, for the time) architecture demanded tight code and well-thought-out routines.

Most chip vendors have extensive application notes that give real-world application advice for their products. Intel has a wonderfully complete guide to implementing a completely software-resident UART on the 8085; the guide is still probably the best general description of this concept. National's series of notes about convolutions and signal processing serves as a good introduction to these important and underutilized concepts. Linear-circuit vendors discuss aliasing, A/D conversion, and other data-acquisition techniques.

Always save code. Reinventing the wheel is always foolish. Look for and save code fragments that implement various functions. If you're writing an expression processor, you could use techniques that you or an associate wrote years ago, or use the algorithm in Macrackin's Fortran book.

The biggest problem with collecting algorithms is evaluating their usefulness. You must ask yourself such questions as whether a particular routine really works, what the boundary conditions are, and how efficient it is. Before using an unknown approach, you should study the algorithm critically. Engineers can use their mathematics background to analyze the concepts, but far too many computer science graduates have little understanding of and training in math.

In sum, learn from others. Actively seek out alternative ways of solving problems, and save those solutions for the future. As your Collection grows, your increased productivity will earn you a reputation as a technical wizard of the first order.

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Modern Electronic Packaging (seminar), San Diego, CA. Technology Seminars Inc, Box 487, Lutherville, MD 21093. (301) 269-4102. March 20 to 22.

DCA Forecast to Industry (seminar), Tyson Corner, VA. Janie Herring, AFCEA NOVA Chapter, The BDM Corp, 7915 Jones Branch Dr, McLean, VA 22101. (703) 848-6944. March 27 to 28.

IBM Personal Computer Interfacing for Scientific Instrument Automation (workshop), Blacksburg, VA. Linda Leffel, Donaldson Brown Center for Continuing Education, Virginia Tech, Blacksburg, VA 24061. (703) 961-4848. March 27 to 29.

1989 Technical Symposia on Aerospace Sensing, Orlando, FL. The International Society for Optical Engineering (SPIE), Box 10, Bellingham, WA 98227. (206) 676-3290; in Europe: SPIE, Koblenzer Strasse 34, D-5300 Bonn 2, West Germany. (49228) 361546. TWX 172-283-747. March 27 to 31.

Southcon/89, Atlanta, GA. Alexes Razevich, Southcon/89, 8110 Airport Blvd, Los Angeles, CA 90045. (213) 772-2965. March 28 to 30.

CASE Benchmarks: A Seminar Comparing Leading CASE Tools, New York, NY. Digital Consulting Inc, 6 Windsor St, Andover, MA 01810. (508) 470-3880. April 3 to 5.

Digital Signal Processing, Single-Chip DSP Processors, Development Systems—Theory, Designs and Applications (seminar), Cambridge, MA. Dr Amnon Aliphas, DSP Associates, 18 Peregrine Rd, Newton, MA 02159. (617) 964-3817. April 3 to 5.

Commercially Available Reduced-Instruction-Set Computer Processors (seminar), Cambridge, MA. Dr Amnon Aliphas, DSP Associates,

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CIRCLE NO 73

CALENDAR

18 Peregrine Rd, Newton, MA 02159. (617) 964-3817. April 5 to 7.

Electronic Imaging Conference West, Pasadena, CA. MG Expositions Group, 1050 Commonwealth Ave, Boston, MA 02215. (800) 223-7126; in MA, (617) 232-3976. April 10 to 13.

The 1989 Facsimile & Image Communications Conference, Orlando, FL. Kristin Fischer, CAP International, 1 Longwater Circle, Norwell, MA 02061. (617) 982-9500. April 12 to 14.

Modern Electronic Packaging (seminar), Baltimore, MD. Technology Seminars Inc, Box 487, Lutherville, MD 21093. (301) 269-4102. April 18 to 20.

12th Annual IEEE Design for Testability Workshop, Vail, CO. T W Williams, IEEE Subcommittee on DFT, IBM Corp, Box 1900, Boulder, CO 80302. April 18 to 21.

The Computer-Aided Software Engineering Symposium, Boston, MA. Elizabeth C Barnaby, Digital Consulting Inc, 6 Windsor St, Andover, MA 01810. (508) 475-6990. April 24 to 26.

Improved Reliability Through Environmental Stress Screening (seminar), Milwaukee, WI. John T Snedeker, Center for Continuing Engineering Education, University of Wisconsin-Milwaukee, 929 N Sixth St, Milwaukee, WI 53203. (414) 227-3120. May 3 to 5.

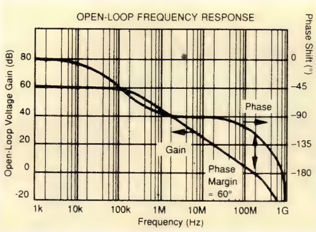
Modern Electronic Packaging (seminar), Chicago, IL. Technology Seminars Inc, Box 487, Lutherville, MD 21093. (301) 269-4102. May 10 to 12.

Custom Integrated Circuits Conference, San Diego, CA. Marc Hartranft, Cypress Semiconductor, 3901 N First St, San Jose, CA 95134. (408) 943-2681. May 15 to 18.

INTRODUCING

OPA620 THE COMPLETE VIDEO/RF AMP

OPA620 is a versatile new op amp for video, RF, and other high speed signal processing applications. It provides exceptional speed, accuracy, and output drive in a very easy-to-use monolithic design.

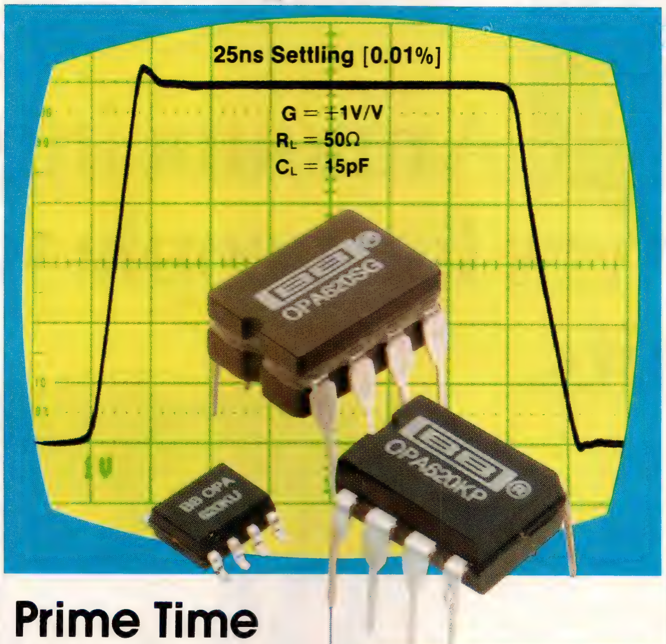


Outstanding Gain/Phase Performance

Fast Driver!

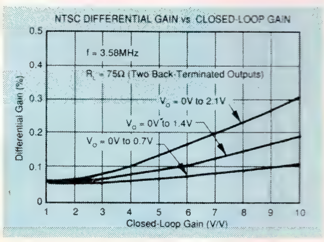
OPA620 has all the speed needed for RF/video buffering, PLL amplification, peak detecting, and signal distribution applications. Plus, its high current output lets you drive multiple cables and other heavy loads easily and economically.

- Gain-bandwidth, 200MHz (G = +10V/V)
- Settling time, 13ns to 0.1% 25ns to 0.01%
- Slew rate, 250V/μs
- Output drive, $\pm$3.0V into 50Ω
- Offset voltage, $\pm$100μV
- Drift, 8μV/°C
- Noise, 2.3nV/$\sqrt{Hz}$ @ 1MHz

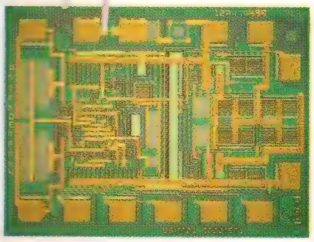


Prime Time Performer

Besides high speed and drive, OPA620 also features very low differential gain (DG) and differential phase (DP) errors, important considerations for many video applications. Both DG and DP are specified at the NTSC sub-carrier frequency of 3.58MHz.



Specified Differential-Gain Error at 3.58MHz



A faster decompensated model, OPA621, is also available offering a 500V/μs slew rate and a gain-bandwidth product of 500MHz.

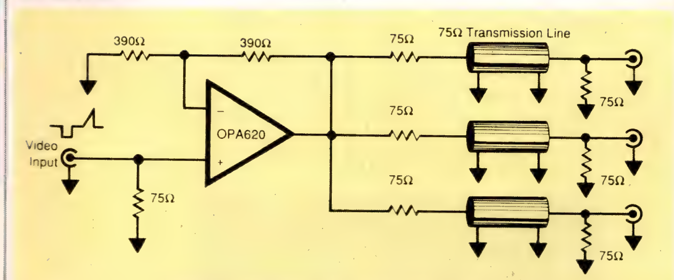
Classic Op Amp Design

OPA620's classic design avoids the problems of asymmetrical inputs and noisy, long settling tails associated with many current-feedback op amps. The unity-gain stable OPA620 settles fast and clean, and it's usable over a wider range of gains. Other key OPA620 features include:

- $\pm$5V supply operation
- Plastic, ceramic, and SOIC package options
- 0/+70°C and −55/+125°C temp ranges
- 150mA internal short-circuit protection

For additional information and assistance, contact your Burr-Brown sales office.

Burr-Brown Corp., P.O. Box 11400, Tucson, AZ 85734.



OPA620 Drives Three 75Ω Transmission Lines

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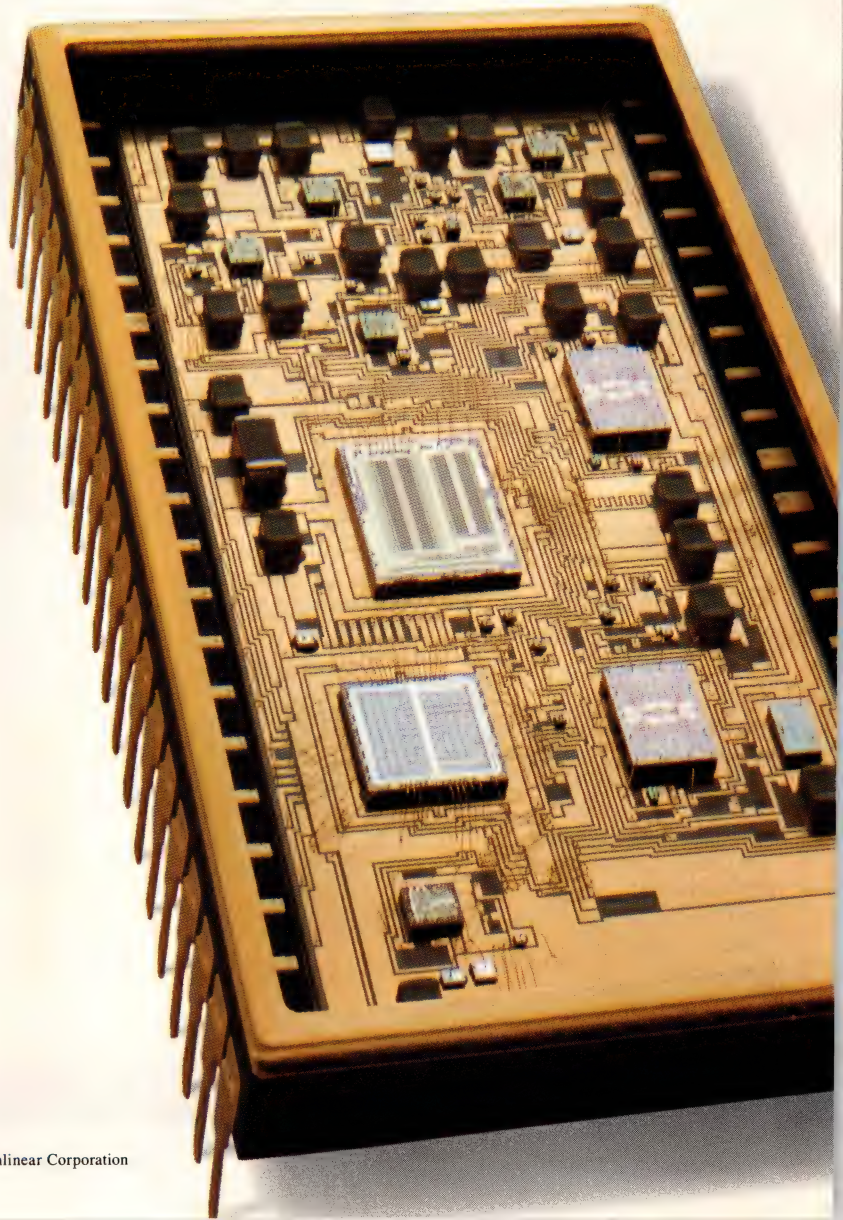
Comlinear brings its high-speed circuit expertise and support to data conversion. We understand your need for responsive suppliers as well as fast parts. We're tuned in. With R&D-level applications engineers to help develop your ideas quicker. Quality documentation and guaranteed specs so you don't waste time. And MIL-STD-1772 certified facility for fast qualification. In your business, time is everything. Count on us for the speed you need.

Announcing data converters for people who push the limits.



These new high-speed data converters from Comlinear push the technology. To help you push the limits in system performance.

They're the A/D and D/A converters you've wanted for high-performance radar systems, high-speed instrumentation, professional video and sophisticated medical equipment.

And in spite of their high performance, they're easy to use. They help simplify your designs. And speed your projects to completion.

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Comlinear Corporation

Solutions with speed

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(303) 226-0500

This 12-bit, 10MSPS A/D is hard to beat... and easy to use.

Comlinear designed the CLC925 as a next generation A/D converter. At 10MSPS, with a 5MHz analog input, SNR is an impressive 68dB. And harmonics are down 70dBc. Perfect for radar processing, electronic imaging, FLIR systems, and high-speed instrumentation.

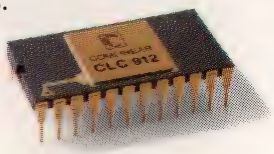
We also made it easy to use with internal track-and-hold, precision voltage reference, error correction, and digital timing circuits. Plus simple gain adjustment. And a 2Vpp input range you can set anywhere between +2V and −2V. All in a 2.1″ × 1.1″ package 40% smaller than the competition. Just connect supplies, an analog input, and a convert signal. You're ready to go. And ask about availability of our 883 version.

12-bit D/A conversion at 25MHz... and no hiccups.

Here's a monolithic 12-bit D/A that's fast... and quiet. The CLC912 handles data conversion rates to 25MHz. And has a low 25pV-sec output glitch energy. Without deglitching circuits. What's more, it has 1LSB integral non-linearity. A 30ns settling time to reconstruct signals with better than 64dB signal purity. And it drives a 50-ohm load to 1V full scale. Directly.

Frequency-domain characterization helps you put it to work in digital frequency synthesis, arbitrary waveform generators, electron-beam positioning systems, professional video reconstruction, and high-resolution A/D converters.

And you can do it simply. Just supply power, a simple reference circuit, a TTL convert signal and data. That's it. You're in business.

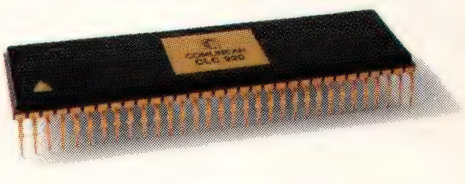


Big performance in a flash... 10-bits and 25MSPS.

This monolithic flash ADC – the CLC920 – can make a big difference in your system's performance. It encodes video-bandwidth input signals at rates to 25MSPS. With 0.1%(max) integral non-linearity. All without an external track-and-hold.

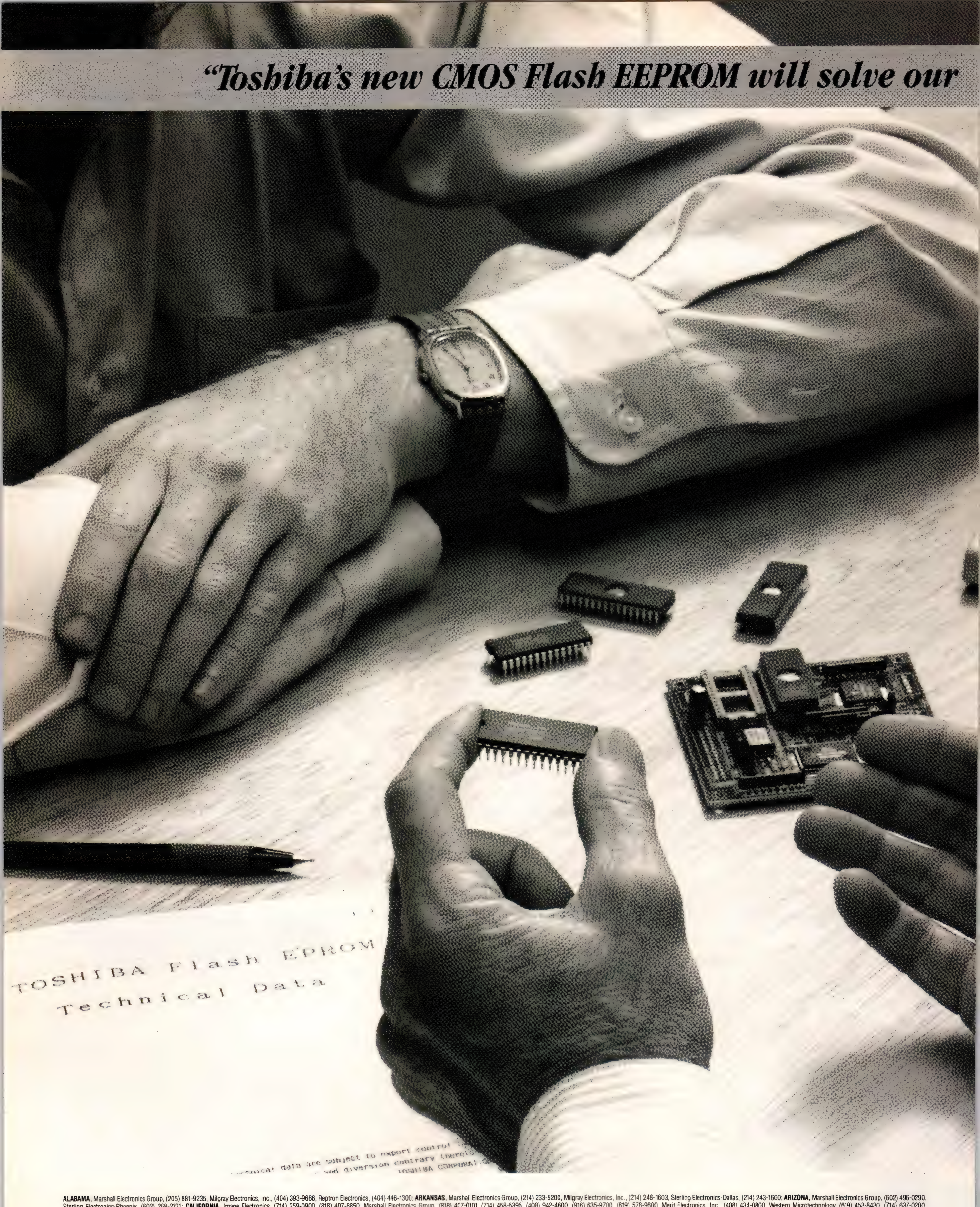
Its 58dB SNR makes it perfect for radar receivers, professional video, waveform analyzers, high-speed instrumentation, and medical imaging.

To help in design, we've characterized the part in the frequency domain. And features like reference sense lines, intermediate ladder tap points, and user configurable data formats deliver high performance with flexibility.



Now, push us for immediate action. Call 303-226-0500 for the details you need... today.

CLC925



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NON-VOLATILE PRODUCT OFFERING

Density	Organization	Type	Process	Access Times (ns)	Package C-DIP	P-DIP	SOG	SOJ
256K	32 x 8	EPROM	NMOS	150 200	X			
		OTP	NMOS	170 200		X	X	
	32K x 8	EPROM	CMOS	70 85 120 150 200	X			
		OTP	CMOS	100 150 200		X	X	
		MROM	CMOS	200		X	X	
		FEEPROM	CMOS	170 200 250		X	X	*
512K	64K x 8	EPROM	NMOS	170 200 250	X			
		OTP	NMOS	200 250		X	X	
	64K x 8	EPROM	CMOS	150 200	X			
		OTP	CMOS	170 200		X	X	
		MROM	CMOS	150 200		X	X	
1 MEG	132K x 8	EPROM	CMOS	150 200	X			
		OTP	CMOS	200 250		X	X	*
		MROM	CMOS	120 150 200		X	X	*
1 MEG	64K x 16	EPROM	CMOS	85 100 150 200	X			
		OTP	CMOS	200 250		X	X	*
		MROM	CMOS	120 150		X	X	*
4 MEG	512K x 8	EPROM	CMOS	150 200	X			
		MROM	CMOS	250		X	X	*

*Indicates this package is under development.

It's available in a 28-pin plastic DIP and a plastic flat pack; both are pin-for-pin compatible with standard 256Kb EPROMs, OTPs and ROMs. Which means it can be placed in existing sockets with no design changes required. By eliminating the separate programming step, the coplanarity of the surface-mount Flash EEPROM is preserved.

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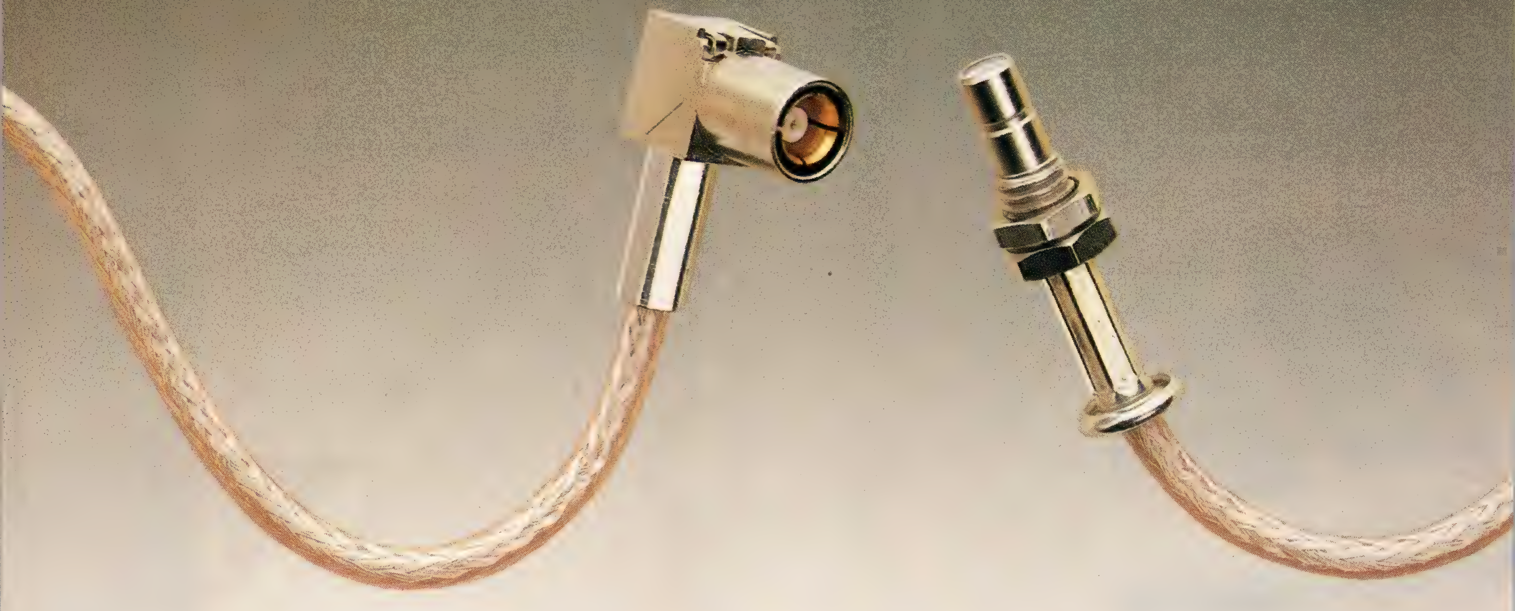
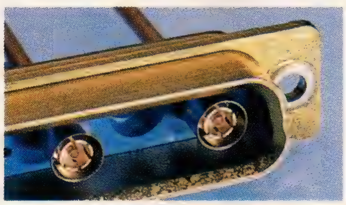


What's

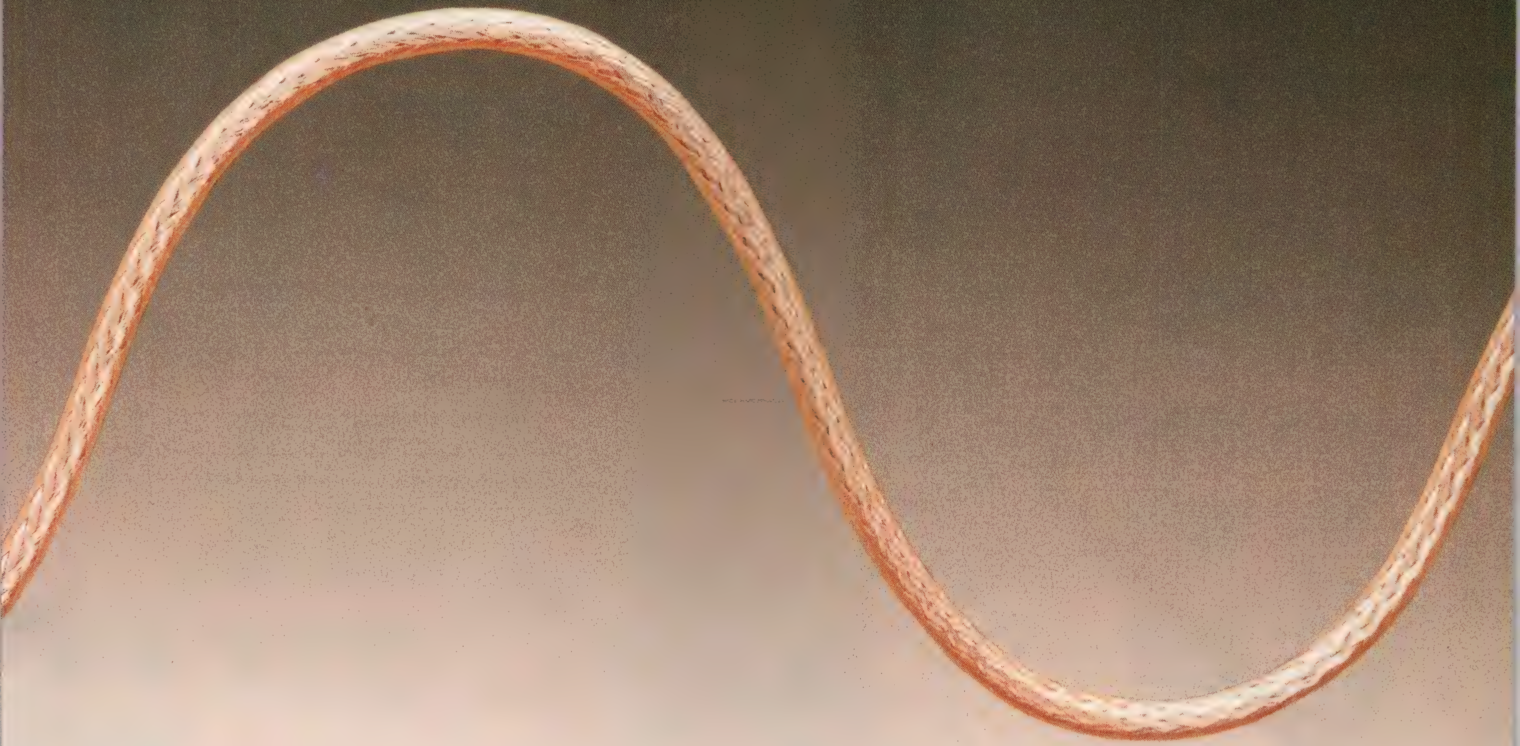
No matter what frequencies you work, you want everything in your connectors that engineering can deliver.

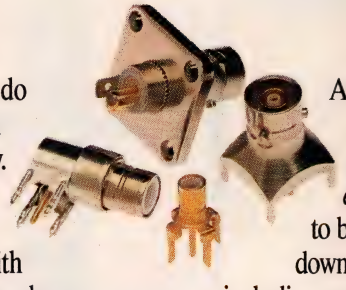


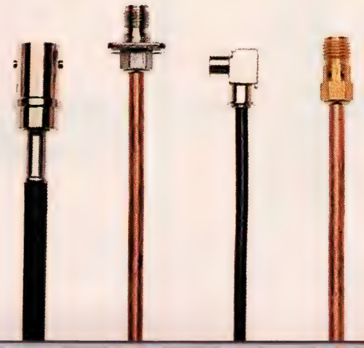
From AMP, that's a great deal.

Our entire line delivers the advanced design and controlled, precision manufacturing you need for top performance, and top productivity. That kind of engineering care is why our "old standards"—from dual-crimp BNCs on up—consistently exhibit Mil-equivalent electrical characteristics. And you can enhance performance even further with a choice of 50 ohm or 75 ohm versions.

Our product offerings cover the spectrum, pushing performance on out







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EDITORIAL

Managers: Phone home

While preparing an article recently, I called over 30 companies to ask for information. I was dumbfounded by many of the responses I got when I asked for product literature and press releases. The people I spoke with were pleasant enough, but when I asked about a product or to talk with sales and marketing people, it was as if I spoke Gaelic. In many cases, the receptionist or secretary didn't know that his or her company made the product I called about. When faced with such a situation, they also didn't know whom to call for help. Some businesses shouldn't complain about foreign competition—they're killing themselves.

To stay in business, you need to know more than who your employees and customers are, what products you manufacture, and who manages them. You must also know whether you're doing a good job communicating with people. Your company's data and specification sheets may be the clearest in the industry, your products may be without equal, and your sales and engineering people may be tops. But all your investments in information, products, and people may be undercut by the people who answer your phones or route your mail. People who don't know what you manufacture and who can't direct potential customers and queries to the right staff person can put you on the road to ruin.

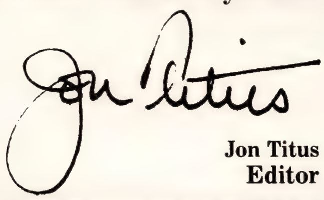
So the next time you're away from your office, give it a call (or have a colleague do it) and try to find someone to talk with about a brand-new or obscure product. Ask for brochures, data sheets, prices, and the name of a local distributor or sales representative. That call should be a good test of your company's or group's ability to handle customers and potential customers in a courteous and efficient manner. The response you get may be shocking.

You can run this test on engineering sections, too. Just call and ask to speak to someone about a design or application problem you have with a brand-new or obsolete product. Have a specific problem in mind, and listen to what sort of information you get. You may be in for another shock.

Some of the worst phone-communication problems are

- People who don't know who manages or oversees a specific product or product line and don't know where to get that information.
- People who don't know what products or types of products their company manufactures and have no idea who should get your call or letter.
- People who are always too busy to return phone calls.
- Electronic-message systems that don't work.
- Secretaries who don't know when the boss will be back, or even where he is. Likewise, they don't know whether or not he's the one you really want to talk to.
- Being put on hold for over 20 seconds without someone offering to take a message.
- Operators who ring extensions and never return to take a message when a phone rings more than 20 times.
- Small companies that use answering services that know neither the company's name nor the name of anyone at the company.
- Companies that employ applications engineers, secretaries, and receptionists for whom English is barely a second language.
- Application engineers who know less about the product than you do.
- Phone answerers who want your life's history before they will tell you that Ms So-and-so is out until next Friday.

I'm sure you can think of a few others. Don't wait for customers and prospects to give you the bad-communication news. Next time you have a chance, give the office a call.



Jon Titus
Editor

Jesse H Neal
Editorial Achievement Awards
1987, 1981 (2), 1978 (2), 1977, 1976, 1975

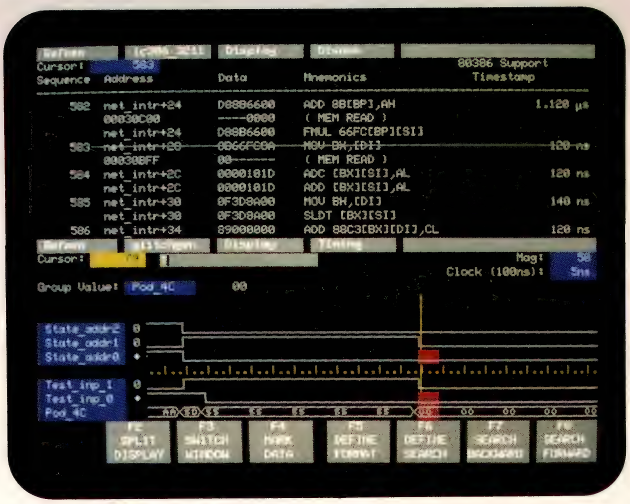
American Society of Business Press Editors Award
1988, 1983, 1981

DAS 9200

Why one hour here saves a week anywhere else.

6 µP's AT ONCE

You may not need this kind of integration capacity today. But you can evolve into it, looking at the interactions of all hardware and software components at



Split screen display of data acquired simultaneously from two microprocessors. The cursors can be locked to scroll in parallel, highlighting data nearest to the same point in time.

NOW WITH FASTER µP SUPPORT.

The DAS 9200 Digital Analysis System: Why poke around for the problem when you can attack it on all sides at once, with the world's most powerful accumulation of digital troubleshooting tools? Now we've boosted DAS 9200 capabilities even further with Release 2 hardware and software... including a new high-speed microprocessor interface that pushes the edge of both RISC and CISC micro support.

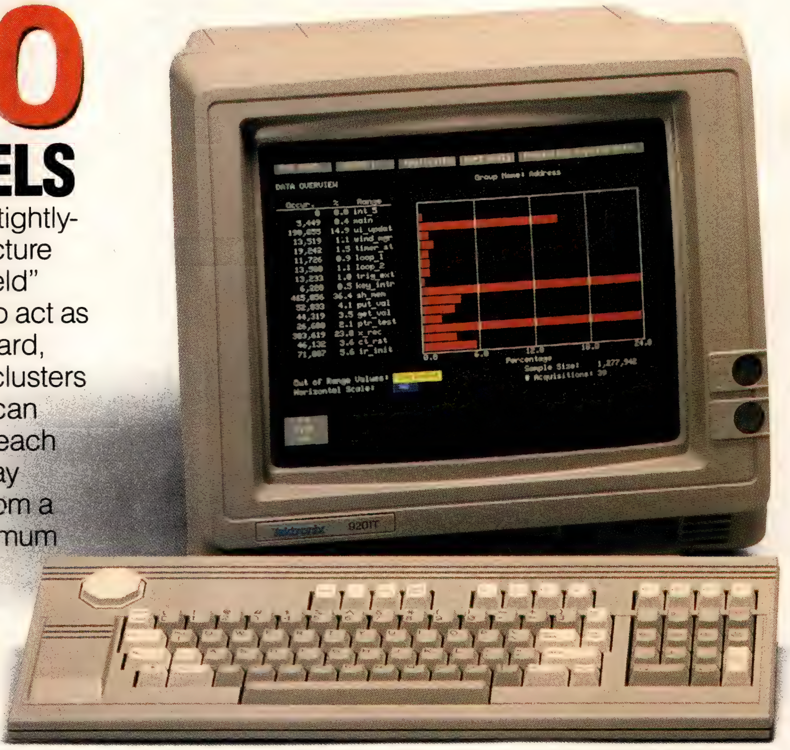
We now offer 33 MHz support for the 68030; 33 MHz for the 68020; 25 MHz for the 88100; and 25 MHz for the 80386—with the capacity for even greater speeds built-in.

128K PER CHANNEL

With the 92A90D acquisition module, you get about 128 times the memory depth of most analyzers. All DAS acquisition cards feature comprehensive triggering, plus selective data suppression, conditional branching, performance analysis, and much more.

540 CHANNELS

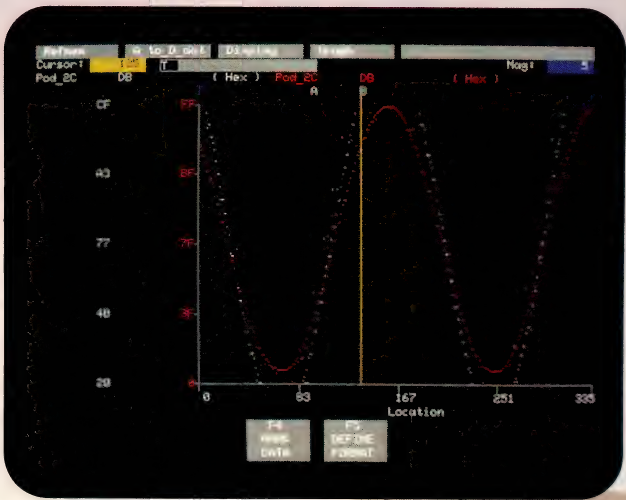
The DAS 9200's tightly-coupled architecture allows you to "weld" cards together to act as a single, wider card, or as individual clusters of modules that can trigger and arm each other, then display information as from a single unit. Maximum configuration: 540 acquisition channels or 1008 stimulus channels.



Version 2

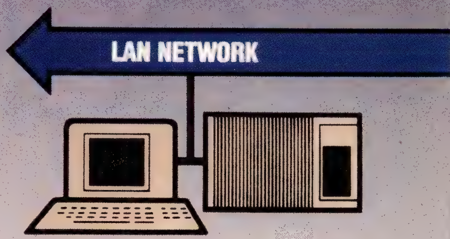
once, with true time-correlation of all data.

Monitor the integration of dedicated I/O processors relative to the Main CPU. Test communications links between processors. Display disassembly activity together with high-resolution timing information to relate logic problems relative to specific events.



2 GHz

For applications requiring nanosecond edge resolution, the 92HS8 High-Speed Timing Module gives you 2 GHz bandwidth and a 500 ps sample interval, supported by a <1 pf input capacitance probe that eliminates common-mode noise and circuit loading. The 92HS8 also welds together to serve wide, parallel applications with no width/speed tradeoffs.

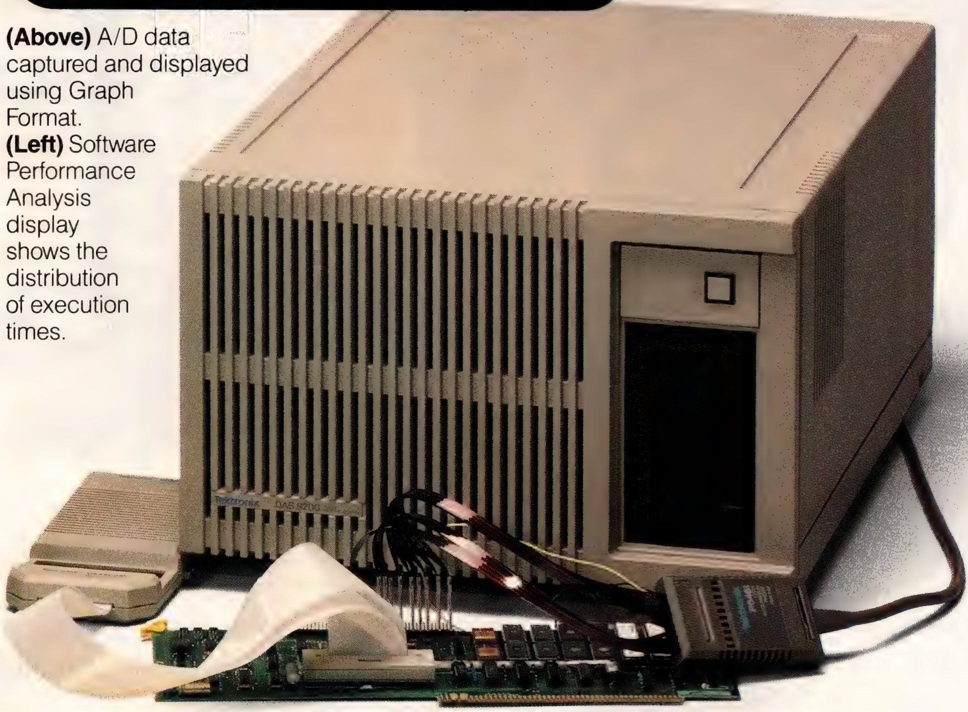


One new asked-for option is the 92LAN card, allowing the DAS to act a network node for efficient file transfer.

Add in its new 8 MB memory for fast response, new 40 MB hard disk, standard, and an assortment of software enhancements, and you see that the DAS not only started in a league by itself. It's staying there.

To find out more about the DAS 9200, contact your Tek representative, or call 1-800-245-2036. In Oregon, 231-1220.

(Above) A/D data captured and displayed using Graph Format.
(Left) Software Performance Analysis display shows the distribution of execution times.



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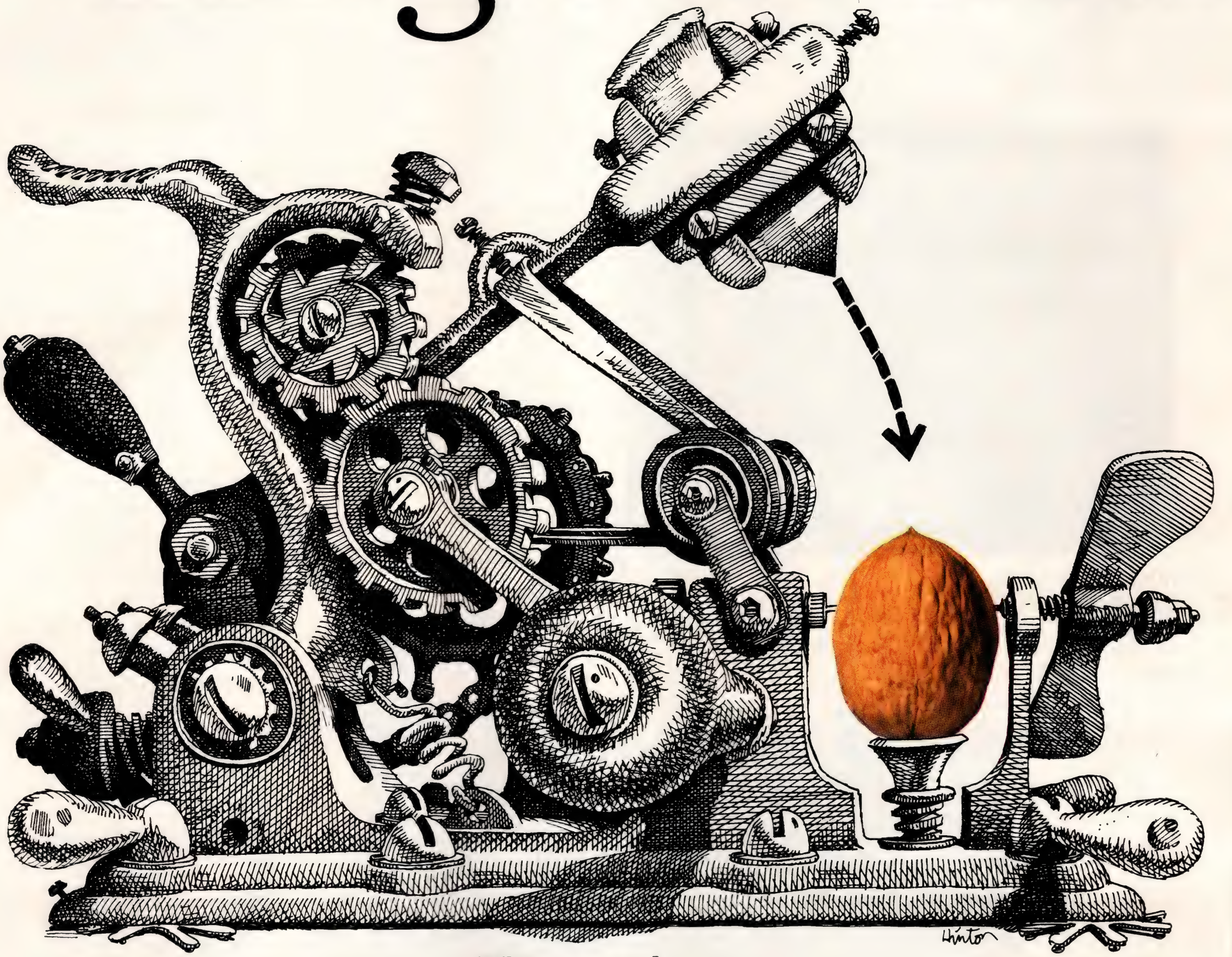


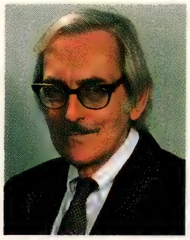
The usual way.

The kind of real-time system you design depends a lot on your real-time development tools. If they're simple, complete and elegant, your solution will be too. And that's why nobody can help you create more elegant embedded systems than Ready.

Our real-time development system is already responsible for helping to generate over fifty million lines of real-time code. And it's the only one based on our CARD (Computer-aided Real-time Design) technology, which was created specifically for the world of real-time. With a unique understanding of the target-host relationship built right in.

We start at the same place you do—with your requirements. And we don't care what you're building, which embedded microprocessor you use, or whether you're working in complex

Smart cards are getting smarter and faster



Who says bigger is better? These miniature microcontroller and memory cards are packed with data, security, and processing capabilities.

Chris Terry,
Associate Editor

A few years ago, when credit-card-size memory cassettes and microcontrollers (smart cards) first became reliable, many observers predicted that the miniature cards would become an immediate success and quickly replace magnetic-stripe cards. Smart cards didn't proliferate as soon as expected, but they're now beginning to appear in an increasing number of applications, including electronic instrumentation, process control, diskless computers for harsh environments, and reconfigurable intelligent peripheral devices, such as printers and point-of-sale terminals. Because smart cards are getting faster and more powerful, the demand for both the memory and the microcontroller cards is growing steadily. Epson, for example, is now delivering nearly 50,000 memory cards per month, compared with 15,000 per month in mid-1987.

Frank Gruppuso, senior vice president of technology development at SmartCard International Inc, points out that in this country, the universal use of magnetic-stripe ATM (automatic teller machine) cards occurred only in the last few years. Despite the disadvantage of limited storage capacity of magnetic-stripe cards, the investment in magnetic cards, readers, and software is so great that the United States' banking industry won't quickly switch to other methods. More likely, he concludes, the smart-card technology will gradually penetrate the financial world, and the two technologies will exist concurrently for a while.

This gradual transition is already apparent in France and Japan, where smart cards are used for general financial purposes. Visa is experimenting with smart cards in a pilot project that embraces cash advances and point-of-sale credit transactions. Further, a machine currently under development speeds up the credit-card verification procedure by checking your credit card against a list of invalid numbers contained in an EEPROM smart card. The machine eliminates the need to phone an authorizing agency, and a built-in modem allows the retailer to update the list by downloading the latest version of the list from the authorizing agency's computer.

The memory-type smart cards may even relegate bubble memory—once touted as the ideal storage medium for harsh environments—to the status

The credit-card-size memory cards *from Fujisoku offer 8k to 64k bytes of EEPROM, 256k bytes of battery-backed RAM, or 1M bytes of EPROM or mask ROM.*

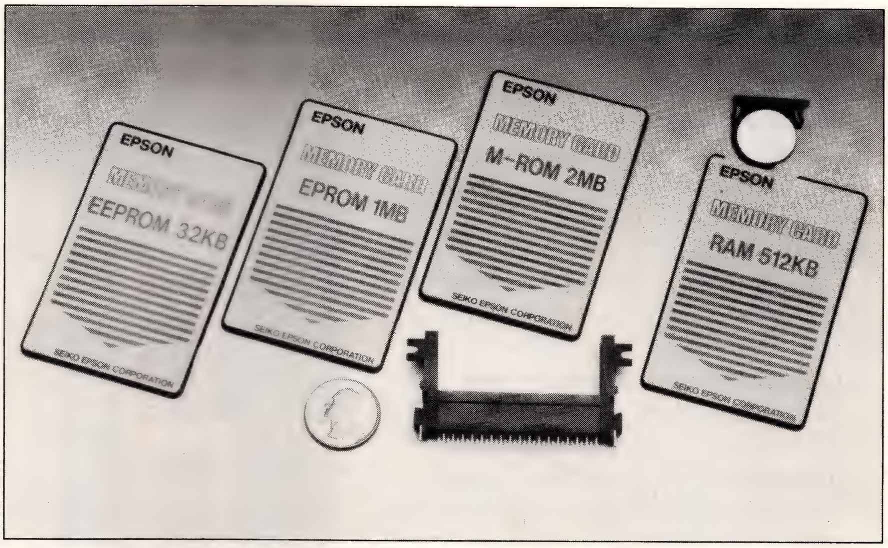
Smart cards

of "an interesting idea that didn't make it." Compared with bubble memory, smart cards take up far less space, are much faster (their 150-to 300-nsec access time compares to the millisecond access times of bubble memory) and, because they use CMOS technology, consume far less power than bubble memory.

You can now obtain memory cards that have capacities ranging from 8k bytes to as many as 2M bytes and offer static RAM, nonvolatile EEPROM, one-shot PROM, and mask ROM. Epson, for example, offers 150-nsec static-RAM cards with capacities from 8k to 512k bytes. A built-in battery, which has a life of three to five years, maintains recorded data when the card is unplugged. To replace the battery without losing the data, you can plug the card into a reader, which supplies the operating voltage.

Like most vendors' memory cards, Epson's standard cards are 8 bits wide so they can fit in the bus structure of the majority of microcontroller chips. However, you can now order memory cards with a 16-bit word width. The total bit capacity remains the same—that is, you can configure a 64k-bit capacity as 8k bytes or as 4k 16-bit words.

All of Epson's memory cards include a special connector that grounds the case and signal grounds before grounding any other lines. The vendor claims that this system provides more than the typical 25-kV protection built into the card and prevents damage caused by EMI noise and static electricity. The 8-bit, one-shot PROM cards start at \$14.10 (5000); prices for the 16-bit cards start at approximately \$14.40. Epson also offers EPROM and EEPROM programmers: A stand-alone programmer that connects to an IBM PC via a serial link costs \$960, and an adapter that plugs into Data I/O or Stag programmers costs \$150.



To prevent unauthorized access to data, *Epson's memory cards include logic that recognizes passwords, personal identification numbers, or keys.*

A recent entry into the smart-card field is Fujisoku, which first began developing smart cards in 1982. This vendor now distributes its products in the United States through Shigma Inc. Its cards feature static RAM, EEPROM, EPROM, one-shot PROM, and mask ROM and range in size from 8k to 64k bytes of EEPROM, 256k bytes of battery-backed RAM, and 1M byte of EPROM or mask ROM. Prices vary from \$18 for 8k bytes of static RAM to \$98 for 1M byte of mask ROM (5000).

Other suppliers of smart memory cards include Dallas Semiconductor (Dallas, TX), Du Pont Connector Systems (New Cumberland, PA), and Mitsubishi Electronics America Inc (Sunnyvale, CA); their products are described in an earlier EDN article **(Ref 1)**.

μC cards handle complex tasks

Memory cards are becoming more useful in applications that require modest amounts of data to be portable and updatable and that put the main burden of security on the host system. The lower levels of security can be handled by on-card custom logic that recognizes keys, passwords, personal identification numbers (PINs), and other simple access permissions; more elaborate security measures such as encryption, however, require processing power either on the card or in the card reader or host computer. Applications that need processing power rather than large amounts of memory include intelligent machines, appliances, computer peripherals, laboratory instruments, and environmental-control systems.

The microcontrollers currently offered in the standard ISO card size (85×54 mm) have an 8-bit architecture and embody 128 to 256 bytes of RAM workspace, 3k to 6k bytes of mask ROM to hold the operating system and application program, and 2k to 16k bytes of EEPROM to hold the user data. A built-in serial link provides communication to the outside world at transfer rates as high as 9600 bps.

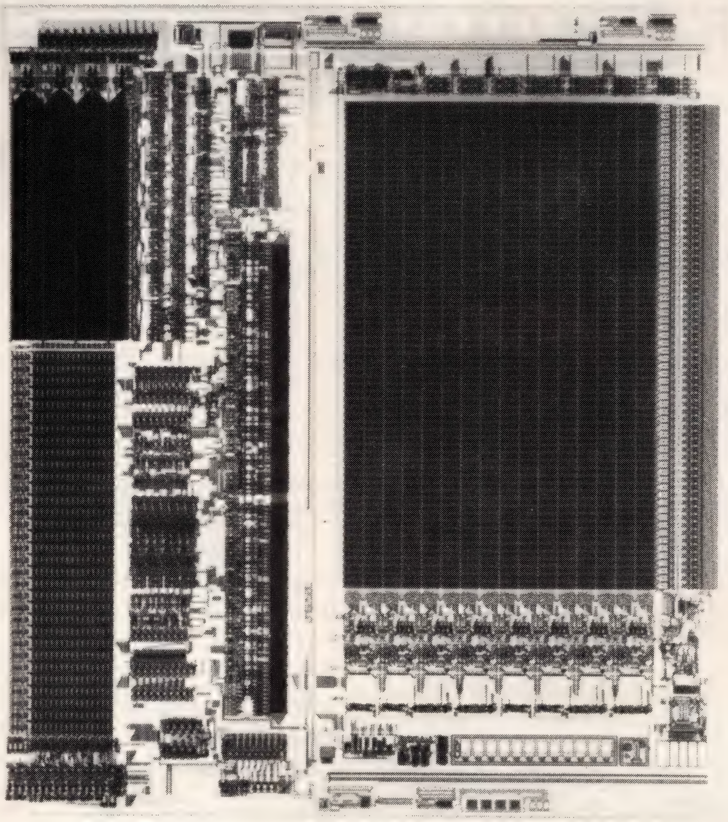
The 8-bit architecture and the proportion of volatile to nonvolatile memory are determined partly by the needs of the applications and partly by manufacturing constraints. Eight-bit processors are

the smallest processors that satisfy the internationally accepted standards for processing some types of information within specified time intervals. Despite these constraints, 8-bit processors have enough computing power to handle most applications.

Paul Grimme, a tactical marketing manager for microcontroller division of Motorola, points out that both marketing and physical considerations affect configurations (**Ref 2**). The more features incorporated in a processor, the larger the silicon die area must be; the larger the die area is, the fewer good units you can expect from a wafer—resulting in a higher cost per unit. In addition, the physical size of the die should not exceed 6×6 mm. Dies that are larger than this practical limit tend to break when the cards in which they are embedded are embossed or subjected to bending stress.

The Magnacard line of microcontroller cards from SmartCard International Inc comply with these various configuration constraints. The units have an 8-bit architecture and contain a low-power CMOS processor, 128 bytes of RAM workspace, 3k bytes of ROM, and 2k bytes of EEPROM. The software contained in the ROM not only provides a multilevel security structure guarded by password, PIN, or key access protocols, but also lets you partition the data memory to hold multiple, independent data sets. Each data set can have its own security level and access method. The ROM-resident operating system is responsible for the low-level storage and retrieval of data within the EEPROM; the card reader can access files by name alone and does not have to handle physical memory addresses.

The microcontroller cards conform to the ISO standards for size (85×54×0.76 mm), extra magnetic-stripe facilities (ISO tracks 1, 2, 3), embossing area (ISO STDs 7810 and 7811), and card contacts (ISO DIS 7816/2). Printing can be placed over the entire card surface except on the contact area and the magnetic-stripe area. Current prices for the Magnacard line vary from $5 to $10 per card (OEM quantities), depending on the features you request. Frank Gruppuso, senior vice president of technology development at SmartCard International, is confident that when order volumes reach 250,000 or more, the price per card will fall below $5.



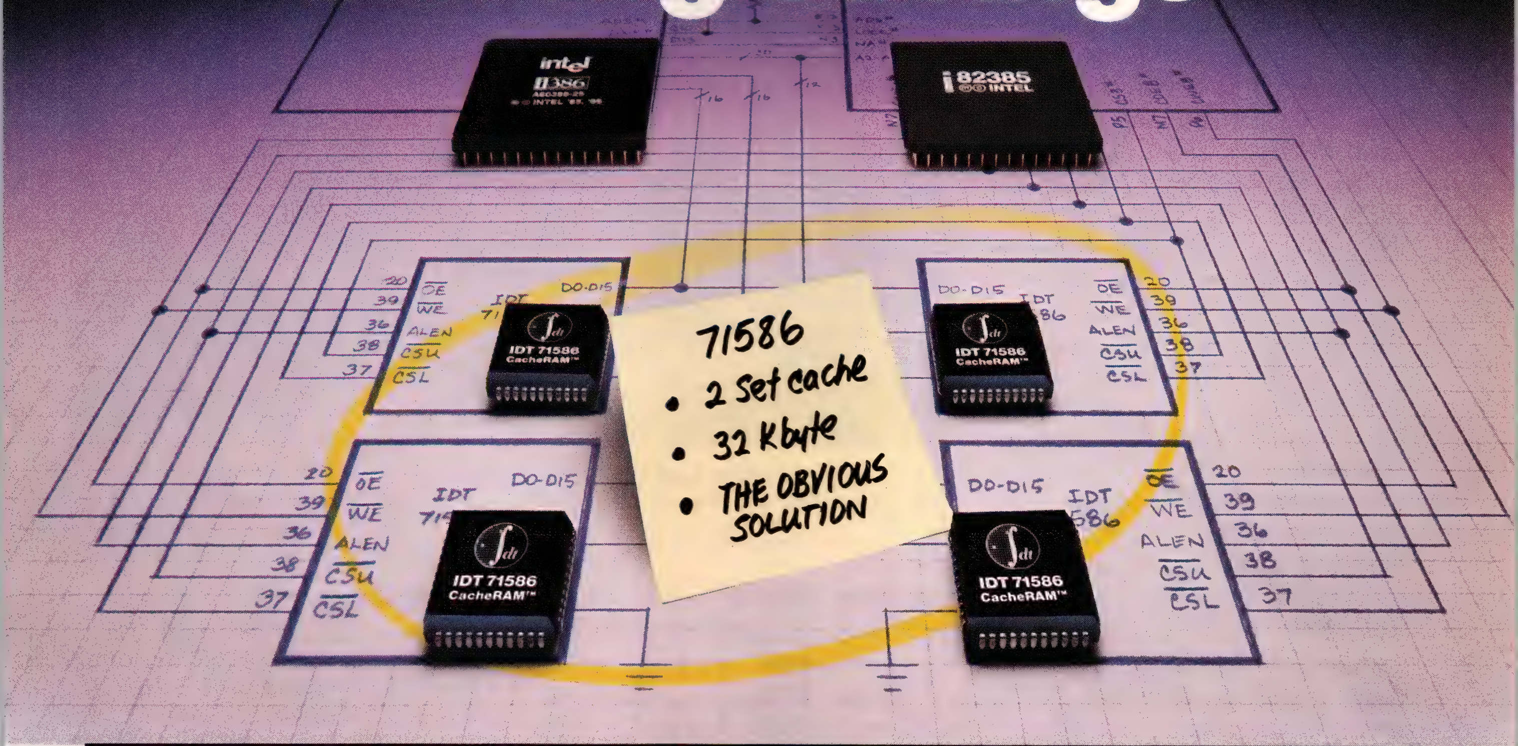
The CAT62C780 smart card *from Catalyst contains an 8-bit CPU, 6k bytes of ROM, 192 bytes of RAM, and 8k bytes of EEPROM.*

Catalyst Semiconductor Inc, offers two microcontroller smart cards, the CAT62C580 and the CAT62C780. The main difference between the cards is their memory allocations: the CAT62C580 has 3k bytes of ROM, 128 bytes of RAM, and 2k bytes of EEPROM; the corresponding capacities of the CAT62C780 are 6k bytes, 192 bytes, and 8k bytes. The CAT62C780 is priced at $60 (100).

Put a PC/XT in your pocket

The Wildcard-88 from Intel is a miniature pc card that features many of the same manufacturing techniques as memory and microcontroller cards. The 2×4-in. card contains an 8088 CPU and all the logic of an IBM PC/XT mother board. The 8088 CPU and a custom gate array are mounted by chip-on-board technology; the gate array re-

Turn Your Cache Into Big Savings



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Now you can replace 27 ICs with only 5 chips using our new CacheRAM™, the IDT 71586. You can save two-thirds of your board space and reduce power consumption by a third. The IDT 71586 makes the ideal 2-set associative, 32 K byte cache. Optimized for Intel's 82385 cache controller, the IDT 71586 matches 25 MHz Intel80386™ designs with its 35 ns access time.

386™/82385 CLOCK FREQ.	IDT 71586 SPEED
16 MHz	55 ns
20 MHz	45 ns
25 MHz	35 ns
—	25 ns

Big Savings In Board Space

With on-board address latches and byte enables, the IDT 71586 eliminates extra transceivers and latches in your design. Each CacheRAM's 8 K byte capacity replaces four 2 K byte SRAMs and lets you save at least 4 square inches of critical board space. All because it's designed specifically for high-speed 386™/82385 caches. Fewer chips also means lower power requirements — typically less than 1.5 watts for 32 K bytes of data storage.

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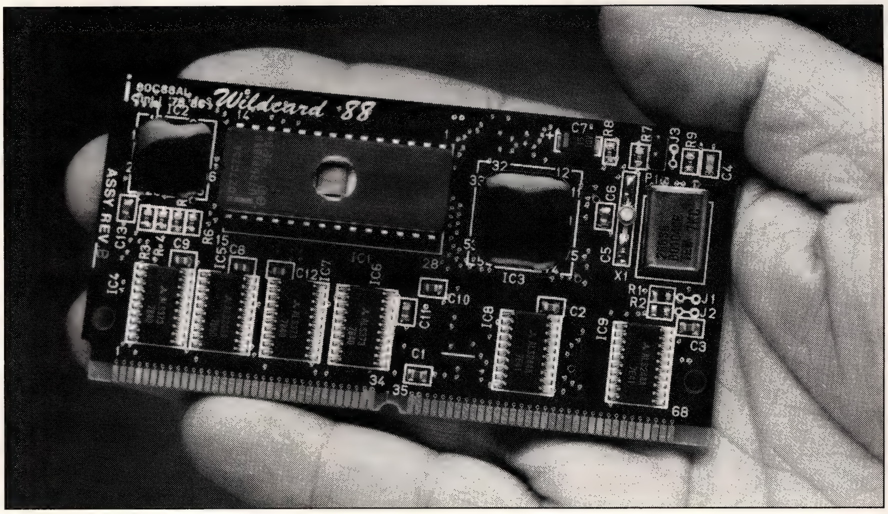
CIRCLE NO 78

places the DMA controller, counter-timer chip, parallel I/O port, interrupt controller, and bus controller of the IBM PC/XT. Wildcard-88 has an IC socket that can hold a 32k-byte BIOS PROM, and the Wildcard-88N has a socket that can hold an 8087 numeric coprocessor. The remaining six surface-mounted chips are bus drivers that bring the standard IBM PC/XT bus out to the 68-pin miniature connector. The Wildcard-88 costs $50, and the Wildcard-88N costs $55 (1000).

Intel developed the Wildcard-88 for use in intelligent laboratory instruments and other peripheral devices that work in conjunction with a centralized host IBM PC or compatible and need processing power for data acquisition and local processing. However, many other applications are possible; the card is small enough to fit in telephones, medical diagnostic instruments, thermostats and sensor boxes for environmental control systems, and systems that require MS-DOS compatibility embedded in their individual components.

Deborah Conrad, manager of strategic communications for the microcomputer components group, says that Intel is developing a version of the Wildcard-88 that is the same size as the original version but has 256k bytes of onboard RAM. Intel has not specified when this unit will appear.

The possibilities for miniaturization are endless. Perhaps in a few years we'll see a corresponding shrinkage of display technology or a diskless IBM PC/AT with a projection system in a box that is no larger than a carton of cigarettes. Of course, shrinking a standard keyboard may not be possible, but with improved (and shrunk) voice-recognition circuits, a keyboard may no longer be necessary. Shades of HAL 9000! EDN



A gate array fits all the logic *of an IBM PC/XT mother board on a 2×4-in. card called Wildcard-88. The miniature connector carries all the signals of the standard IBM PC/XT bus.*

References

1. Terry, Chris, "Smart cards yield high memory capacities for mass-storage and data-security uses," *EDN*, October 1, 1987, pg 61.

2. Grimme, Paul, "Smart Card Silicon Manufacturing and Technology Trends," *Proceedings of the Smart Card Applications and Technology Conference*, Information Exchange, Falls Church, VA, 1988.

Article Interest Quotient
(Circle One)
High 518 Medium 519 Low 520

For more information . . .

For more information on the smart-card products discussed in this article, contact the following manufacturers directly, circle the appropriate numbers on the Information Retrieval Service card, or use EDN's Express Request service.

Catalyst Semiconductor Inc
2231 Calle de Luna
Santa Clara, CA 95054
(408) 748-7700
FAX 408-980-8209
Circle No 707

Epson America Inc
3415 Kashiwa St
Component Sales Dept
Torrance, CA 90505
(213) 534-4500
Circle No 708

Intel Corp
3065 Bowers Ave
Santa Clara, CA 95051
(408) 765-4758
Circle No 709

Shigma Inc
80 Martin Lane
Elk Grove Village, IL 60007
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CIRCLE NO 79

Plug-in power sources simplify system design

Bus-specific plug-in power sources can reduce both mechanical and electrical problems that plague the configuration phase of system design.

Tom Ormond,
Senior Editor

If you're about to configure a VME Bus system, you can simplify the process by using plug-in power sources—units that slide directly into the system's card cage. The sources' compact design alleviates the mechanical problems associated with mounting your power supply as well as the electrical problems that arise when you connect your supply to the card cage. You may have to pay a little more up front for these power sources, but their benefits pay off both during and after the design process.

The power sources' convenient packaging significantly reduces the amount of time you need to develop a system. As a result, you can reduce both the overall cost of the design and the factory-to-market time—a key ingredient in the success or failure of any product. The plug-in concept can also provide long-term savings for the system's end user. If problems arise, the user can easily replace a defective power source, thereby eliminating expensive service calls and minimizing the system's down time.

Most importantly, you don't have to trade off performance for convenience. Plug-in units that operate from either ac or dc inputs are available. The units offer control signals that are in accordance with the VME specification and feature a wide range of highly regulated output levels. In addition, plug-in power sources meet the international safety standards and satisfy VDE and FCC EMI requirements.

Because of the wealth of available power sources, you'll find yourself in the optimum situation for system designers—exploiting a buyer's market. Considering the variety of power-source inputs, outputs, and power capabilities, you can easily select a plug-in power source that will complement most any application.

Total Power International is one of several vendors offering plug-in power supplies that work from ac inputs. Its

Boasting a 50,000-hour MTBF, *NCR's triple-output supplies comply with DIN 41494 for Eurocard packaging and meet UL, CSA, and TUV (VME) standards for safety and EMI.*

shape up!

Introducing

the Lean, Mean Power Machine . . .

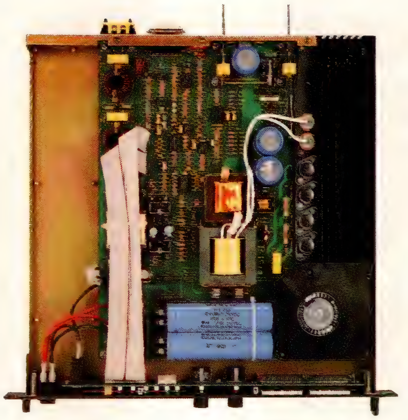
the DCS Series from Sorensen.

Say good-bye to the unwanted pounds of oversized conventional power supplies. Sorensen's new DCS offers a lean profile with heavyweight features.

Tipping the scale at a slim 19 pounds, the compact DCS leaves more space in your rack or on your bench for other equipment. Don't let the small size fool you—the DCS packs a powerful 1000 watt punch, incorporating a current mode control, full forward converter, employing 100 kHz switching technology for high power density in a lightweight package with high reliability.

Eight DCS models provide 0-8 Vdc to 0-600 Vdc output and current levels from 1.7 A to 125 A with a 1% line and load regulation. Standard features include remote programming of voltage, current, over-voltage protection, and remote sensing of output voltage, as well as selectable programming ranges. The DCS has 115/230 Vac selectable, 47-63 Hz single phase input and is designed to meet FCC Class A requirements.

For its compact size, the DCS has plenty of extra room for future options.



MODEL	Voltage VDC	Current ADC
DCS-8-125	8	125
DCS-20-50	20	50
DCS-40-25	40	25
DCS-60-18	60	18
DCS-80-13	80	13
DCS-150-7	150	7
DCS-300-3.5	300	3.5
DCS-600-1.7	600	1.7

And Sorensen backs this innovative power supply with a 5-year warranty.

The Sorensen name is known for quality engineering and technical superiority. We manufacture a complete line of power supply products suitable for ATE, bench-top, OEM, and burn-in applications. All units are immediately available from stock and are supported by a knowledgeable team of engineers who can customize or modify existing products for special requirements.

Why put up with out of shape power supplies when the DCS will handle your power supply workout. Flex your muscle—specify the lean, mean power machine from Sorensen.

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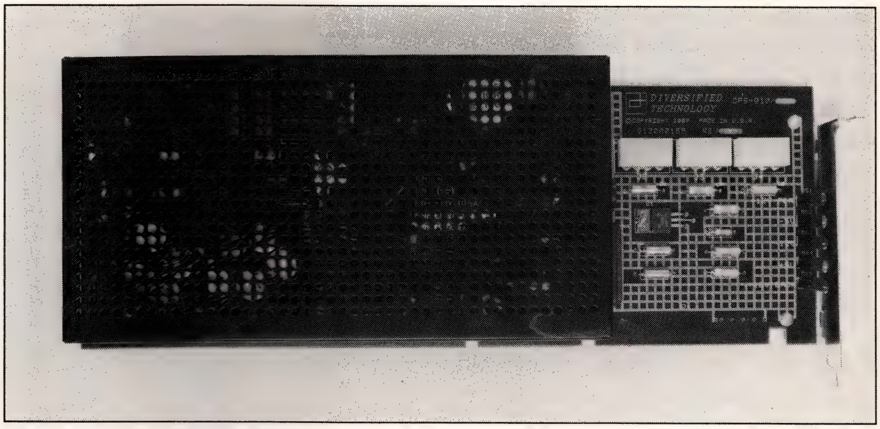
Bus-specific sources

HSU Eurocard/VME Series switching supplies mount easily into standard Eurocard/VME rack systems. The 3U-high (5.25-in.) supplies are available in three widths: 6 TE (1.2 in.), 8 TE (1.6 in.), and 10 TE (2.0 in.). They come in single-, dual-, and triple-isolated-output versions, which cover output voltages of 5, 12, 15, and 24V. Their output power ratings range from 45 to 100W. The dual-and triple-output versions feature auxiliary outputs, which come with or without post regulators.

The supplies in the HSU Series employ a 100-kHz forward-converter circuit design and provide a typical efficiency of 75%. They operate over a 47- to 440-Hz frequency range and feature user-selectable inputs from 90 to 132 or 180 to 264V ac. In addition, their input lines are fuse protected.

The HSU supplies include a 0.4% typ line regulation and a 1% typ main-output load regulation for a 50 to 100% load change. For the same load step, the load regulation measures 5% typ for auxiliary outputs that don't have a post regulator and 1.5% typ for models whose auxiliary outputs feature a post regulator. The supplies' noise and ripple are 2% max p-p, and the transient response is less than 0.5 μsec for a 50% load change.

All supplies in the line feature overvoltage protection circuitry, which activates when any of the outputs' average power exceeds 110% of the maximum rating. The supplies meet all international safety standards and comply with the VDE 0871-B and the FCC B-curve EMI requirements. The models have a front-panel green LED power-on indicator and a pull-out handle. Dual adjustable outputs and power-fail signals are optional. Prices for the HSU Series 45 and 100W versions range from $102 to $139 (100).



In addition to providing power for an IBM PC/AT computer, *Diversified Technology's plug-in power supplies can also provide power to peripheral devices such as disk or tape drives.*

NCR's contribution to the plug-in-supply market is the H2ACL-051212, a triple-output, 200W switching supply. This unit complies with both the IEC-297 standards and the Eurocard packaging system defined in DIN-41494. In addition, they are fully certified to the safety requirements of UL, CSA, and TUV (VDE).

The maximum capabilities for the H2ACL051212's outputs are 5V/20A, 12V/6A, and −12V/4A. Its line and load regulation is ±0.4% max, and its typical efficiency is 73% at nominal input line level and full load. The device includes a 50-mV p-p max noise and ripple specification, a 25-msec typ holdup time after the loss of input voltage, and a ±2% adjustability on the main 5V output. It also has ac-fail and system-reset signals, a 500,000-hour MTBF, and an operating range of 0 to 50°C without derating.

The unit's proper supply performance is immediately verifiable; 200 to 500 msec after you turn on the unit, a TTL-compatible open-collector signal verifies that the output power is within the specified tolerances. You can control the supply from a remote location, using a 2.4V dc TTL signal to enable the supply and an open-collector signal to disable the supply. It interfaces with the VME Bus via a direct plug-in connection. The unit, which costs $277 (1000), is configured in a 1.588×10.3×6.4-in. package and weighs 3 lbs.

Satisfy your power needs

Because your application may need more than 200W, many vendors also offer high-power VME supplies. The VME003 from Schroff is a 270W, 6U-type supply that operates from 110 or 220V ac sources (40 to 400 Hz). Its typical efficiency is 75%. The supply's outputs are permanently protected against short circuits and maintain better than 0.1% regulation over 0 to 100% load conditions.

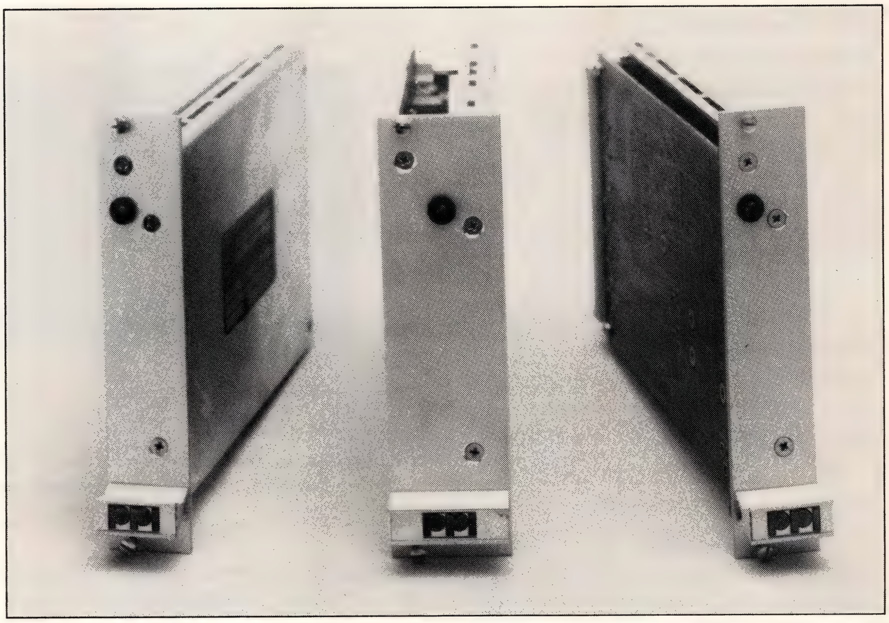
The supply operates over a 0 to 50°C range and provides outputs of 5, 12, and −12V at currents of 35, 6, and 2A, respectively. Alternatively, you can distribute the load between the 12 and −12V outputs to obtain a 9A max current capability. The VME003 provides ac-fail and system-reset signals in accordance with the VME Bus specification and features soft start and current foldback. The VME003 is priced at $1260 and comes with two male connectors that meet DIN 41612, Type H 15 requirements.

In the event of an input failure, the supply maintains output voltages at full load for approximately

Bus-specific sources

16 msec. The response thresholds for the overvoltage protection circuitry are set at the factory. A built-in response delay of approximately 3 msec prevents nuisance triggering in case short voltage peaks occur. The convenient front-panel LEDs provide status information for the input and all output voltages.

Some manufacturers, such as Power Pac and Lambda, offer product lines with an extraordinary amount of supplies to choose from. The VMEP Series of ac-input power supplies from Power Pac, for example, comprises 104 units. Ranging in price from \$375 to \$1335, the supplies provide a variety of voltages and as much as 800W of regulated power in VME Bus format. The line consists of four subgroups with power ratings of 200, 400, 600, and 800W. Each subgroup includes 13 6U-high versions and 13 3U-high models.



The VMEC Series switch-mode dc/dc converters *from Power Pac are available in 3U-high packages. The single-input version supplies 2 to 48V, and the dual-output version supplies 2 to 24V.*

All models in the line offer three outputs in various combinations of 5, 12, 15, 24, and 48V. Their output-current capability ranges from 1.8 to 34A for the 200W versions, 3.6 to 68A for the 400W models, 5.4 to 102A for the 600W units, and 7.2 to 134A for the 800W models. The output response time and the noise and ripple are 400 μsec and 50 mV, respectively.

The VMEP supplies, which operate from 115 or 230V ac, have fully isolated ac outputs. You can connect the supplies in parallel and use their power-sharing capability. All of the supplies' outputs include overvoltage, overcurrent, and brownout protection. The brownout protection circuitry allows the supplies to maintain full output when input voltages are as low as 85 or 160V ac. The front panel contains a power switch and four indicators for input- and output-voltage status information.

The supplies' efficiency ranges from 70 to 80%, and their regulation is ±0.2%. Their logic interfaces include remote inhibit, ac fail, and system reset. They are designed to operate in standard VME Bus card racks; however, if you want to conserve card-slot space, the supplies are available in versions that you can mount outside the rack.

Lambda also makes a sizable contribution to the supply market; its LI Series includes over 90 units with voltages from 2 to 48V. The plug-in supplies come in single- and triple-output versions that provide from 15 to 150W.

Operating over a frequency range of 47 to 440 Hz, the supplies accept inputs of 95 to 132 or 187 to 65V. Their efficiencies range from 55% for the 2V models to 75% min for the 12 through 48V units. The supplies can operate over a 0 to 40°C range without derating. Overvoltage protection is standard on all single-output models and on the main output of triple-output versions.

Regulation for line and load are 0.1 and 0.2%, respectively. The supplies include a provision for remote sensing, which allows you to eliminate the effects of the output lead resistance on dc regulation of the single-output versions. All models remain within regulation limits for at least 20 msec after the loss of ac power. The LI Series single-output devices cost from \$129 to \$270 (100). You can order the supplies either in chassis form with front panels or as open pc boards. Each package uses the type-H15 connector and measures 3U in height.

Take your pick of inputs

Many plug-in supplies not only provide the convenience of a slide-in design, but also give you the option of operating from a dc source. Melcher's VE Series power modules, for instance, provide three highly regulated dc voltages from an unregulated 24V dc input. Two input filters, two switching regulators, and a dc/dc converter are arranged on a double-sized (233.4 × 160 × 1.6-mm) Eurocard. An additional monitor circuit limits each module's input current to 15A and generates the VME-specific

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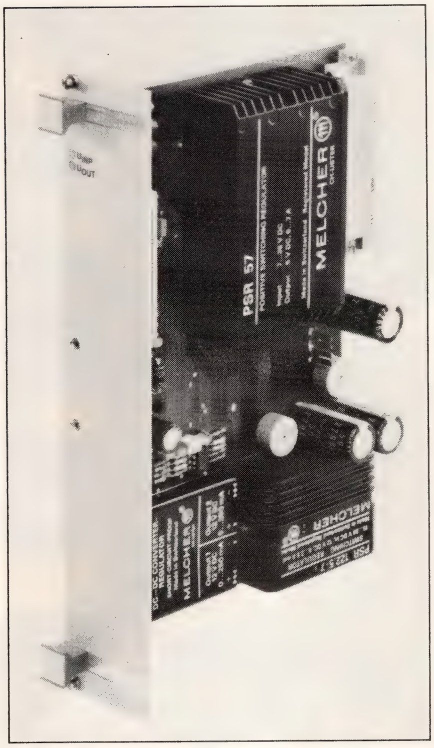
CIRCLE NO 97

SPRAGUE

Bus-specific sources



Featuring an 84W output power capability, *Melcher's triple-output dc/dc converters provide the VME-specific power-fail and system-reset signals. The converters operate over a 0 to 55°C range without derating and offer 80% typ conversion efficiency.*

power-fail and system-reset signals, which include open collector, 10 mA, and TTL level.

The main outputs for the VE Series power modules are 5V/5A for the 3021 model, 5V/7A for the 3022 model, and 5V/12A for the 3023 model. All three versions provide auxiliary outputs of 12V at 1.5A and −12V at 0.5A; the total output power levels range from 49 to 84W. The output ripple and the load transient recovery time are 50 mV p-p and 500 μsec, respectively.

The supplies' monitoring circuitry provides overvoltage, overtemperature, and undervoltage protection, and their LED monitors provide input- and output-voltage status information. Two diodes at the input provide reverse-polarity protection.

The modules in the VE-3000 Series operate over a 0 to 55°C range without derating. Their efficiency is 80% typ and is constant over the entire input voltage range. Outputs are located at a female connector, which complies with DIN 41612 requirements. The MTBF is 200,000 hours, and the static control deviation vs input voltage is 0.01%. The VE-3000 power modules are available for $480 (100).

Increase your output options

In addition to its ac-input power supplies, Power Pac offers the VMEC Series of switch-mode dc/dc converters. Designed specifically for VME Bus applications, they serve as subsystem components and draw their dc input from one of the outputs of the VMEP supply. This capability allows users to develop one or two (or more) dc levels that might not be available from the primary system supply. The VMEC units can also work in a stand-alone mode, drawing their input from any suitable dc source.

The converters are available in single- and dual-output models, which feature either 40 or 80W. Their output-voltage levels range from 2 to 48V, and their current capability ranges from 0.8 to 16A. The 40W packages, which cost $127, measure 5.6×1 in., and the 80W modules, which cost $169, measure 5.6×1.4 in. If you order any two units with similar widths, you can have them assembled on a single 6U panel; the cost of this assembly is double the single-piece price.

The converters feature a choice of inputs ranging from 10 to 18 or 20 to 36V (jumper-selected at the factory), a ±5% or ±0.5V output adjustment range, a ±0.1% line regulation, a ±0.2% load regulation for a 0 to 100% load change, a 1% or 50-mV ripple and noise specification, a 0.02% temperature coefficient, and a 400-μsec response time

For more information . . .

For more information on the plug-in power sources discussed in this article, contact the following manufacturers directly, circle the appropriate numbers on the Information Retrieval Service card, or use EDN's Express Request service.

Diversified Technology Inc
Box 748
Ridgeland, MS 39158
(601) 856-4121
FAX 601-856-2888
Circle No 700

Lambda Electronics
515 Broad Hollow Rd
Melville, NY 11747
(516) 694-4200
FAX 516-293-0519
Circle No 701

Melcher Inc
200 Butterfield Dr
Ashland, MA 01721
(508) 881-4715
FAX 508-879-8669
Circle No 702

NCR Power Systems
3200 Lake Emma Rd
Lake Mary, FL 32746
(407) 323-9250
FAX 407-323-3434
Circle No 703

Power Pac Inc
Box 777
Norwalk, CT 06856
(203) 866-4484
FAX 203-866-4487
Circle No 704

Schroff Inc
170 Commerce Dr
Warwick, RI 02886
(401) 732-3770
FAX 401-738-7988
TLX 952175
Circle No 705

Total Power International Inc
418 Bridge St
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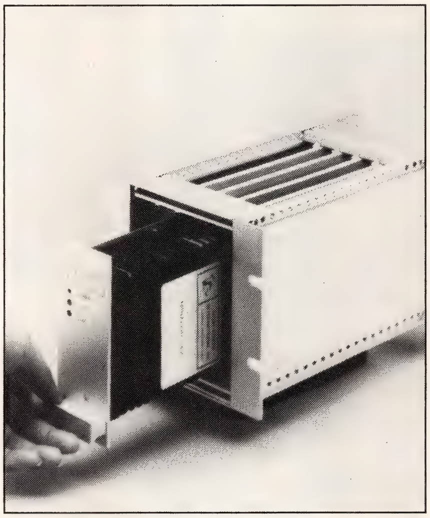
CIRCLE NO 102

Bus-specific sources



Providing a typical efficiency of 75%, *HSU Series supplies from Total Power International are available in single-, dual-, and triple-output versions, which offer from 45 to 100W of output power.*

for a ±25% load change. The operating range spans 0 to 50°C without derating.

All the VMEC converters feature EMI filtering, remote sensing capability, 750V input-to-output isolation, and efficiencies ranging from 55% min for 2V outputs to 80% min for 12V and higher outputs. Overload and overvoltage protection are standard. The input and output connections use 15-contact, DIN 42612-type connectors.

Get some computer power

For some applications, you need a plug-in power supply for a system that is more specific than the general-purpose VME Bus system. You can, for example, use Diversified Technology's CPS710/80 or CPS710/150 single-board, multiple-output, switching power supplies, which plug into a standard IBM PC/AT card slot. They deliver maximum outputs of 80 and 150W.

The supplies' inputs are user-selectable for operation over 90 to 132 or 180 to 264V ac, 47 to 63 Hz. The CPS710/80 provides outputs of 5V/8A, 12V/1.2A, −12V/0.4A, and −5V/0.1A. The CPS710/150 provides the same voltages at currents of 15, 1.5, 0.8, and 0.1A, respectively. These outputs for the backplane are located on the card-edge connector in the supply module. The supplies also feature three connectors that provide power (12V at 2.5 and 5A for the CPS710/80 and the CPS710/150, respectively) for peripheral devices such as disk and tape drives.

The two supplies maintain output voltage at full load down to 90/180V ac for brownout protection. They also feature overload and short-circuit protection circuitry; this circuitry will automatically recover upon removal of the overload condition.

The units have a 20-msec hold-up time at full-rated load. Their output noise is 0.3% rms, and their efficiency ranges from 65 to 75%, depending on how you distribute the load among the outputs. Further, they meet the safety and dimensional requirements of both domestic and international (VDE) standards. In quantities of 100, the prices for the CPS710/80 and CPS710/150 are $195 and $395. EDN

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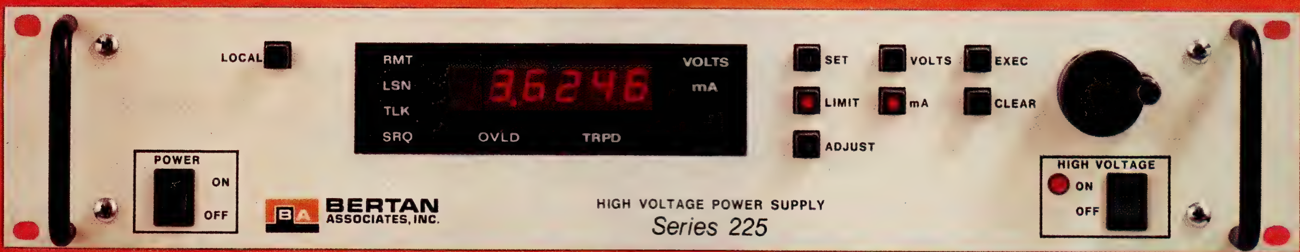

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CIRCLE NO 99

SPECIAL EDITIO

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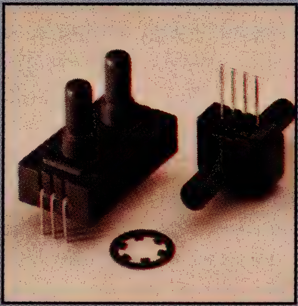

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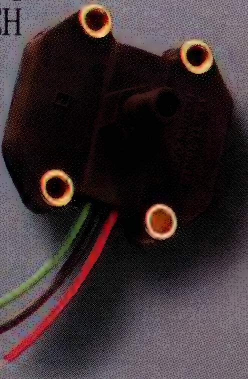

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CIRCLE NO 98

SHOW PREVIEW

Electro melds technical and personal concerns

April is not exactly peak tourist time in New York City. But if you're interested in furthering your professional knowledge, there will be plenty of sights to see.

Joan Morrow,
Assistant Managing Editor

About 45,000 engineering professionals will head to New York City next month to attend the annual Electro gathering. The Jacob K Javits Convention Center is the venue for this year's show; April 11 to the 13 are the dates. As usual, you'll have the opportunity to see exhibits and demonstrations of computers, peripherals, software, instruments, testing equipment, fiber-optic devices, and components. What's unusual this year is a special exhibit that will be devoted to demonstrations of CAD/CAE systems for automated design.

Catching up on the state of the art in product development is not the sole reason to attend the show. Of equal importance is the line-up of professional sessions that Electro/89 will offer. The comprehensive, 25-session program, which is divided into six tracks, will cover new technologies, automated design/semiconductors/systems, communications, video technology, professional and personal concerns, and entrepreneurial activities.

What to choose?

Superconductivity—a topic that has received much attention in general-interest and technical publications—will also receive ample coverage at Electro. It's the subject of a tutorial and a session in the track on new technologies (see the professional-program schedule for dates and times). **Session 6** will review the development of high-temperature superconductors and provide a glimpse at recent progress in this high-interest technology. Other sessions in this track will cover nanoelectronics, new applications for electro-optical components, dealing with electromagnetic interference, and the personal computer as a scientific and engineering productivity tool.

The track on automated design/semiconductors/systems will feature two hot topics—VHDL and RISCs. Papers in **session 17** will introduce VHDL (VHSIC (very high-speed IC) Hardware Description Language), EDIF (Electronic Design Interchange Format), and IGES (Initial Graphics Exchange Standard) and go over applications and future directions of these standards. The latest RISC applications and devices will be addressed in five papers in **session 16**, including the VL86C020, the 29000 family, and the 88000. Space enthusiasts might want to attend **session 24** in this track, which will cover progress in space photography, also known as remote sensing. The final paper in this session is slated to give a glimpse of video photography from the Space Shuttle.

The latest developments in high-

Electro®/89

ELECTRO PROFESSIONAL-PROGRAM SCHEDULE

TUESDAY APRIL 11, 1989 10 AM TO NOON	**SESSION 1** SUCCESSFUL SYSTEM DESIGN TECHNIQUES USING ASICs	**SESSION 2** CHALLENGES FOR THE ENGINEER IN THE NEXT DECADE	**SESSION 3** MICROWAVE TECHNOLOGY	ELECTRONIC THEATER* DIGITAL VIDEO INTERACTIVE SYSTEMS	**SESSION 4** HIGH DENSITY PROGRAMMABLE LOGIC DEVICES AND THEIR DESIGN TOOLS	**TUTORIAL** SUPERCONDUCTORS IN INSTRUMENTATION AND STANDARDS 9 AM TO NOON
1:30 PM TO 3:30 PM	**SESSION 5** 16/32 BIT MICROCONTROLLER'S—SOFTWARE AND HARDWARE FEATURES	**SESSION 6** SUPERCONDUCTIVITY: TECHNOLOGY/ APPLICATIONS	**SESSION 7** FIBER OPTICS NETWORKS	ELECTRONIC THEATER ACM/SIGGRAPH REVIEW	**SESSION 8** NANOELECTRONICS	**TUTORIAL** LEGAL CHALLENGES TO MANAGING THE WORKPLACE 1 PM TO 4:30 PM
WEDNESDAY APRIL 12, 1989 10 AM TO NOON	**SESSION 9** OPPORTUNITIES FOR EXPERIENCED ENGINEERS	**SESSION 10** NEW TRENDS IN MICROWAVE, MILLIMETER-WAVE AND PHOTONIC DEVICE TECHNOLOGY	**SESSION 11** PROGRAM PRODUCTION IN HIGH DEFINITION TELEVISION	ELECTRONIC THEATER* HIGH TECH VIDEOS	**SESSION 12** WOMEN IN ENGINEERING	**TUTORIAL** INTELLECTUAL PROPERTY FOR ENGINEERS AND MANAGERS 9 AM TO 12:30 PM
1:30 PM TO 3:30 PM	**SESSION 13** NEW APPLICATIONS FOR ELECTRO-OPTICAL COMPONENTS	**SESSION 14** VENTURE CAPITAL—AN INGREDIENT BUT ONLY PART OF THE SUCCESS EQUATION	**SESSION 15** TRANSMISSION SYSTEMS FOR HIGH DEFINITION TELEVISION	ELECTRONIC THEATER ACM/SIGGRAPH REVIEW	**SESSION 16** RISC: THE SECOND GENERATION	**TUTORIAL** FUNDING TECHNOLOGY DEVELOPMENT IN SMALL FIRMS 1 PM TO 4:30 PM **TUTORIAL** FIBER-OPTIC COMMUNICATIONS 1 PM TO 4:30 PM
THURSDAY APRIL 13, 1989 10 AM TO NOON	**SESSION 17** WHAT SHOULD YOU KNOW ABOUT VHDL, EDIF AND IGES?	**SESSION 18** MANAGING FOR PROFITABILITY—THE SMART USE OF CONSULTANTS	**SESSION 19** ELECTROMAGNETIC INTERFERENCE—PROBLEMS AND SOLUTIONS	ELECTRONIC THEATER* ACM/SIGGRAPH REVIEW	**SESSION 20** IN-CIRCUIT BOARD PROGRAMMING	**TUTORIAL** HIGH-DEFINITION TELEVISION 9 AM TO 12:30 PM **TUTORIAL** NEURAL NETWORKS 1 PM TO 4:30 PM
1:30 PM TO 3:30 PM	**SESSION 21** ADVANCED LOGIC—MEETING DESIGNER NEEDS	**SESSION 22** PERSONAL COMPUTER FOR AUTOMATIC TEST AND MEASUREMENT	**SESSION 23** MEETING THE NEEDS OF THE EE PROFESSION	**SESSION 24** SPACE PHOTOGRAPHY	**SESSION 25** OFF CAMPUS EDUCATION FOR THE WORKING ENGINEER	**TUTORIAL** TRANSFER IMPEDANCE METHOD OF MEASURING QUALITY OF EMI GASKETED JOINTS AND SHIELDING EFFECTIVENESS OF JOINTS 1 PM TO 4:30 PM

*NOON-1:30 PM EACH DAY: MISCELLANEOUS VIDEOS

definition television (HDTV) will also get its fair share in two sessions in the video technology track. **Session 11** will cover program production in HDTV; **session 15** will discuss the transmission systems for HDTV and give an overview of the technical and regulatory issues. The communications track will give you two opportunities (**sessions 3 and 10**) to review the advances in microwave/millimeter-wave technology, with discussions ranging from materials to current devices and potential applications.

Electro's organizers did not limit the scope of the session topics to technical issues only; a track on professional and personal concerns and a track on entreprenerial activities will round out the show's program. **Session 2** will give you ideas on how to develop and manage your career throughout the 1990s; **session 9** will discuss new jobs for experienced engineers and cover post-retirement opportunities; **session 14** on venture capital will teach you everything you need to know about starting a business; and **session 12** will address areas of concern to women engineers.

For more information on Electro/89, you can contact Electronic Conventions Management at (213) 772-2965. If you can't make it to the show but want information on exhibited products, EDN's March 30, 1989, issue will give you an in-depth look. **EDN**

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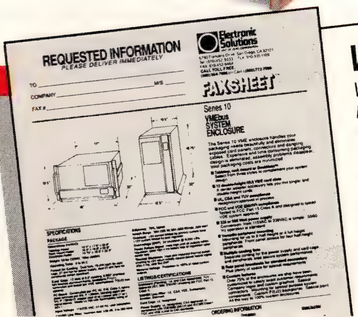

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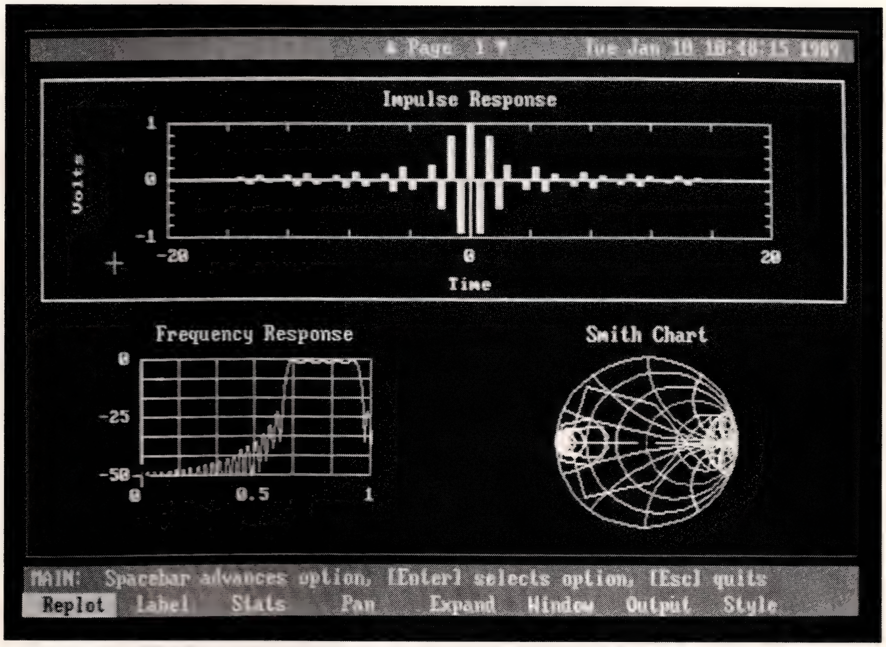
CIRCLE NO 103

Low-priced software manipulates and graphically displays experimental data

Wave is an aggressively priced software package that can control the acquisition of experimental data, then process, display, and print out the data in a variety of easily interpreted forms. Its vendor asserts that the software is much more appropriate for manipulation of experimental data than is a popular and competitively priced "engineering scratchpad" program whose real forte is working with equations and formulas. Other programs designed for manipulating experimental results cost more than Wave does and suffer from limitations that Wave does not impose.



This screen display shows Wave's ability *to plot data in a number of forms. Implicit in the display is the software's capability to manipulate experimental data into easily interpreted displays.*

When you use Wave, only the available disk space limits the size of data sets that represent waveforms. Most competitive software limits waveforms to a size that will fit within the computer's main memory.

The software not only performs all of the functions of an advanced scientific calculator, but also does much more. A few of the items on its long list of capabilities include generating pseudorandom noise, calculating many statistical measures, performing discrete Fourier transforms (DFTs) and inverse DFTs, manipulating matrices, filtering, and smoothing.

The program handles a variety of data types, including waveforms, vectors, matrices, scalars, and strings. It automatically determines the data type based on how you use the data. You can use the program as a personal productivity tool—it includes a spreadsheet-like facility that lets you perform "what-if" analysis. You can also use it to develop data-acquisition and manipulation applications that you distribute to others.

The computer's screen can display several windows with multiple plots in each window. Plots can use linear or logarithmic rectangular coordinates or polar coordinates or they can be in Smith Chart form. The software supports the Hercules and Compaq monochrome graphics standards as well as EGA (enhanced graphics adapter) and VGA (video graphics array) color graphics. You can use an IBM Proprinter, Epson FX or LX series dot-matrix printers, or an HP Laserjet laser printer to obtain graphics printouts.

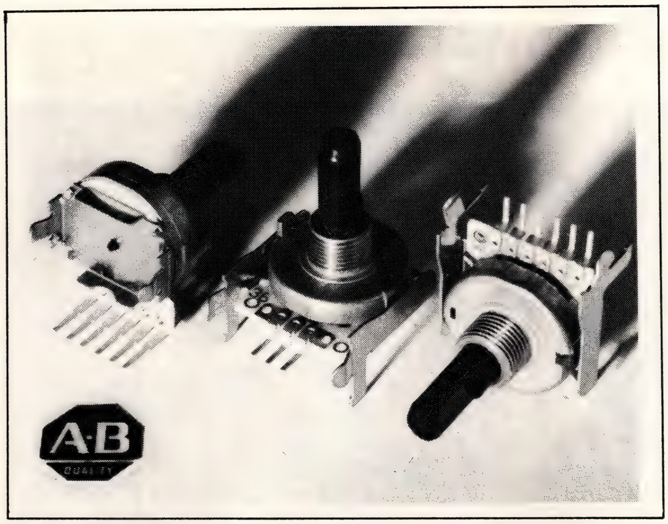
Wave runs under MS-DOS on IBM PCs, PC/XTs, PC/ATs, compatible computers, and PS/2s that have 640k bytes of RAM and a minimum of 2M bytes of disk space. The vendor strongly recommends that the computer also have an 8-MHz or higher clock speed, an 80287 numeric coprocessor chip, and at least 512k bytes of auxiliary RAM that conforms to the Lotus/Intel/Microsoft expanded memory specification (EMS). The software with data-acquisition and analysis modules and a single-user license costs $495.—***Dan Strassberg***

Vespine Corp, 1776 E Washington St, Urbana, IL 61801. Phone (217) 337-3627.

Circle No 730

READERS' CHOICE

Of all the new products covered in EDN's **September 29, 1988**, issue, the ones reprinted here generated the most reader requests for additional information. If you missed them the first time, find out what makes them special: Just circle the appropriate numbers on the Information Retrieval Service card, use EDN's Express Request service, or refer to the indicated pages in our **September 29, 1988**, issue.



▲ ENCODERS

Type EV and EH encoders are available with 2-, 4-, and 5-bit digital outputs that are directly compatible with μPs (pg 207).
Allen-Bradley.
Circle No 601

CONTROLLER IC

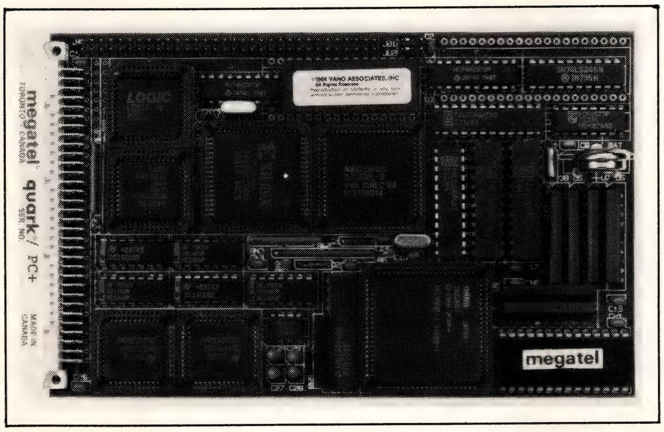
The Am79C401 Integrated Data Protocol Controller (IDPC) combines a data-link controller (DLC), a universal synchronous/asynchronous receiver/transmitter (USART), and a dual-port memory controller (DPMC) in a single IC (pg 114).
Advanced Micro Devices.
Circle No 602

CASE TOOL

POSE (Picture-Oriented Software Engineering) is a CASE tool that consists of nine modules that run independently on machines in the IBM PC and PS/2 families and compatibles (pg 229).
Computer Systems Advisors Inc.
Circle No 604

▲ HANDHELD SCOPES

The T201 and T202 are handheld, 2-channel oscilloscopes. They measure 10×4½×2 in. and weigh less than 2 lbs each with batteries, probe, and carrying case (pg 234).
Tektronix.
Circle No 605



◀ 1-BOARD COMPUTER

The Quark/PC+ single-board computer (SBC) is IBM PC-compatible and has onboard video and disk controllers (pg 222).
Megatel Computer Corp.
Circle No 603

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LEADTIME INDEX

Percentage of respondents

ITEM	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Average (weeks)	Last month's average (weeks)
TRANSFORMERS								
Toroidal	0	7	56	31	6	0	11.0	10.1
Pot-Core	0	13	47	33	7	0	11.0	9.8
Laminate (power)	0	23	62	15	0	0	7.9	7.3
CONNECTORS								
Military panel	0	13	74	0	13	0	9.6	12.0
Flat/Cable	19	24	43	14	0	0	6.3	3.3
Multi-pin circular	8	33	42	17	0	0	6.9	7.6
PC (2-piece)	21	29	43	7	0	0	5.3	6.4
RF/Coaxial	14	43	29	14	0	0	5.7	6.3
Socket	21	46	29	4	0	0	4.3	5.0
Terminal blocks	26	22	43	9	0	0	5.4	5.5
Edge card	16	37	42	5	0	0	5.2	5.4
D-Subminiature	32	23	40	5	0	0	4.6	3.8
Rack & panel	8	50	33	9	0	0	5.5	8.2
Power	14	36	43	7	0	0	5.6	6.6
PRINTED CIRCUIT BOARDS								
Single sided	0	57	43	0	0	0	5.1	4.9
Double sided	0	48	44	0	8	0	6.2	5.0
Multi-layer	0	20	55	25	0	0	8.8	7.8
Prototype	4	80	12	4	0	0	3.9	4.8
RESISTORS								
Carbon film	40	28	32	0	0	0	3.4	4.6
Carbon composition	41	25	19	15	0	0	4.5	3.3
Metal film	39	32	25	4	0	0	3.5	4.0
Metal oxide	35	41	24	0	0	0	3.1	5.9
Wirewound	35	30	30	5	0	0	4.0	5.8
Potentiometers	26	22	37	15	0	0	5.9	4.4
Networks	32	21	42	5	0	0	4.7	4.4
FUSES	52	24	19	5	0	0	3.0	2.4
SWITCHES								
Pushbutton	15	50	30	5	0	0	4.6	5.5
Rotary	14	33	43	10	0	0	5.9	6.9
Rocker	12	41	35	12	0	0	5.8	5.0
Thumbwheel	18	41	29	12	0	0	5.4	7.4
Snap action	7	43	36	14	0	0	6.3	7.6
Momentary	20	33	33	14	0	0	5.8	6.1
Dual-in-line	9	55	27	9	0	0	5.2	7.0
WIRE AND CABLE								
Coaxial	27	33	33	7	0	0	4.7	4.2
Flat ribbon	35	40	20	5	0	0	3.5	3.0
Multiconductor	23	31	32	14	0	0	5.6	4.0
Hookup	38	42	20	0	0	0	2.8	2.2
Wirewrap	42	37	21	0	0	0	2.7	4.3
Power cords	30	30	26	14	0	0	5.1	4.6
POWER SUPPLIES								
Switcher	0	50	33	17	0	0	6.7	7.6
Linear	8	53	31	8	0	0	5.3	8.5
CIRCUIT BREAKERS	14	36	14	36	0	0	7.7	7.1
HEAT SINKS	13	56	25	6	0	0	4.6	4.7
BATTERIES								
Lithium coin cells	43	14	43	0	0	0	3.8	5.0
9V alkaline	70	20	10	0	0	0	1.3	2.6
Real-time clock back-up	14	43	43	0	0	0	4.7	7.6
RELAYS								
General purpose	23	27	14	31	5	0	8.0	7.1
PC board	6	41	12	41	0	0	8.5	9.8
Dry reed	13	13	25	49	0	0	9.9	11.5
Mercury	11	23	33	33	0	0	8.4	11.4
Solid state	7	39	7	40	7	0	9.7	13.5
DISCRETE SEMICONDUCTORS								
Diode	44	8	26	22	0	0	5.7	7.3
Zener	40	16	20	24	0	0	5.8	7.0
Thyristor	29	33	19	19	0	0	5.4	9.4
Small signal transistor	24	32	20	24	0	0	6.2	8.3
MOSFET	25	20	25	30	0	0	7.2	8.2
Power, bipolar	28	22	28	22	0	0	6.3	5.3
INTEGRATED CIRCUITS, DIGITAL								
Advanced CMOS	29	29	24	18	0	0	5.5	7.4
CMOS	26	26	26	22	0	0	6.2	7.1
TTL	42	26	16	16	0	0	4.5	5.7
LS	33	33	17	17	0	0	4.9	5.0
INTEGRATED CIRCUITS, LINEAR								
Communication/Circuit	23	23	31	23	0	0	6.7	6.2
OP amplifier	33	10	33	24	0	0	6.6	4.8
Voltage regulator	21	33	29	17	0	0	5.9	8.4
MEMORY CIRCUITS								
DRAM 16K	11	12	22	44	0	11	12.3	12.2
DRAM 64K	0	12	33	33	11	11	14.3	10.2
DRAM 256K	0	1	44	33	11	11	14.8	9.9
DRAM 1M-bit	0	1	44	33	11	11	14.8	13.1
SRAM 4K × 4	0	12	44	33	0	11	12.4	18.5
SRAM 8K × 8	0	10	27	36	18	9	15.4	14.8
SRAM 2K × 8	0	10	27	45	9	9	14.5	17.5
ROM/PROM	8	17	25	42	0	8	11.4	9.5
EPROM 64K	8	15	38	31	0	8	10.7	9.5
EPROM 256K	7	7	50	29	0	7	10.8	8.8
EPROM 1M-bit	0	10	50	30	0	10	12.2	14.2
EEPROM 16K	8	17	25	42	0	8	11.4	10.8
EEPROM 64K	0	10	36	45	0	9	12.9	14.4
DISPLAYS								
Panel meters	23	54	8	15	0	0	4.5	9.3
Fluorescent	10	40	30	20	0	0	6.6	13.1
CRT 12-inch monochrome	9	45	19	27	0	0	7.0	11.7
LED	9	45	23	23	0	0	6.7	8.8
Liquid crystal	0	25	25	50	0	0	10.4	9.7
MICROPROCESSOR ICs								
8-bit	8	33	17	42	0	0	8.8	7.2
16-bit	15	31	0	54	0	0	9.3	8.9
32-bit	8	17	25	42	8	0	11.0	7.9
FUNCTION PACKAGES								
Amplifier	17	25	33	25	0	0	7.2	10.8
Converter, analog to digital	13	21	33	33	0	0	8.3	12.2
Converter, digital to analog	14	14	36	36	0	0	8.8	10.4
LINE FILTERS	27	19	27	27	0	0	6.9	9.1
CAPACITORS								
Ceramic monolithic	29	25	32	14	0	0	5.4	6.8
Ceramic disc	37	26	26	11	0	0	4.5	5.8
Film	28	30	21	21	0	0	5.8	6.6
Aluminum electrolytic	31	24	28	17	0	0	5.5	5.7
Tantalum	26	22	37	15	0	0	5.9	5.2
INDUCTORS	0	44	28	28	0	0	7.8	11.6

Source: Electronics Purchasing Magazine's survey of buyers.

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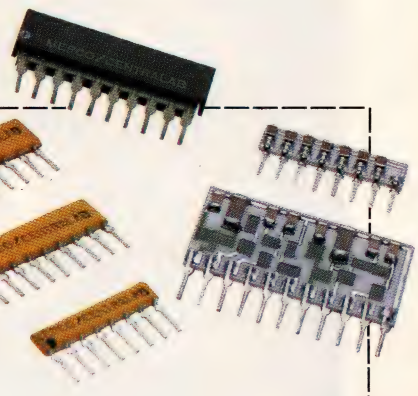

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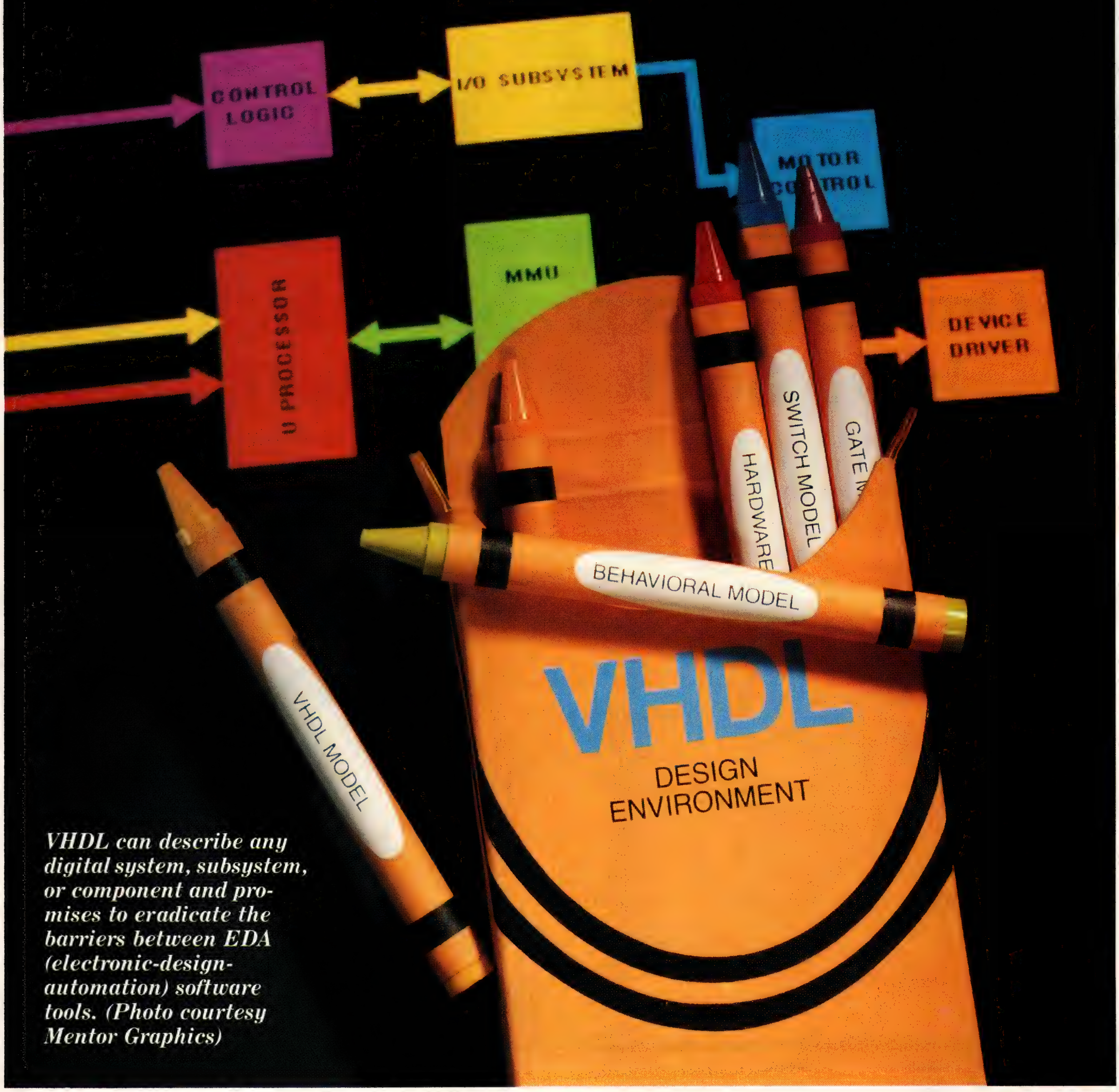
VHDL

VHSIC Hardware Description Language



VHDL can describe any digital system, subsystem, or component and promises to eradicate the barriers between EDA (electronic-design-automation) software tools. (Photo courtesy Mentor Graphics)

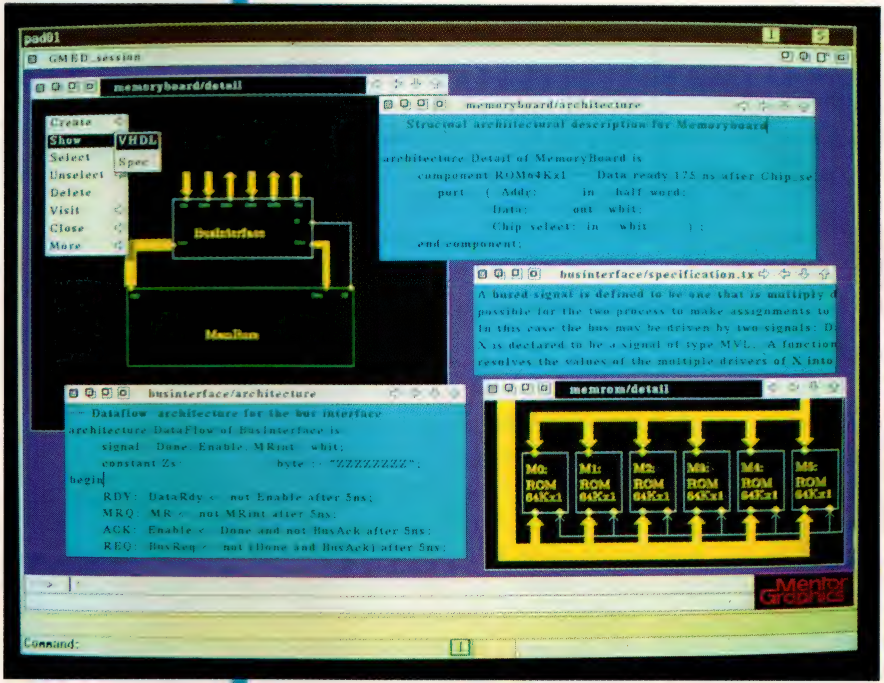
The era of incompatible electronic-design-automation (EDA) tools is drawing to a welcome close. VHDL, the VHSIC Hardware Description Language, can concisely describe any digital electronic part, system, or subsystem using a single, standard dialect. And EDA-tool vendors are scrambling to make their products compatible with the language.

Steven H Leibson, Regional Editor

In the very near future, VHDL—the VHSIC (very high-speed IC) Hardware Description Language—will transform the electronic industry's disjointed collection of design-automation tools into a well-coordinated catalog of compatible software products. VHDL will have this effect on EDA (electronic-design-automation) tools because the language has capabilities far beyond its designers' original purpose of describing VHSIC chips: VHDL's semantics can describe any digital system or component. Further, the language's syntax enables you to create system descriptions that you can simulate. This ability lets you verify your design before building a prototype or even creating a detailed design. Though more than 100 hardware-description languages (HDLs) predate the arrival of VHDL, its standardization as IEEE-1076 makes it the first truly industry-standard HDL.

Today, EDA-tool vendors find themselves in much the same predicament that America's railroads encountered in the early 19th century. When railroad technology was first developing, every railroad line used a different track gauge. If you shipped goods to a destination that required a change of carrier, the cargo had to be manually transferred from the boxcars of one line to those of another because the tracks' gauge difference prevented cars from traveling on more than one railroad line. In much the same way, many of today's competing EDA tools do not share data easily. Often, you must transfer engineering data files between software packages manually. VHDL proms to eradicate the barriers between EDA software tools. Because of its widespread applicability to digital system design, VHDL will have an impact on digital-system-design methods similar to that of 7400 series TTL logic.

As one of the primary consumers of products developed with EDA tools, the US Department of Defense (DoD) has moved against tool incompatibility and in favor of a standard documentation format. Per MIL-STD-454L, Requirement 64, paragraph 4.5.1, all digital ASICs designed after September 30, 1988, that are used to fulfill defense contracts must be documented using behavioral and structural VHDL descriptions. This rule is really just the first step in the DoD's efforts



***Because VHDL can describe** a logic block's behavior apart from its structure, you can create operating models of a system at the architectural level before designing any circuirty, as illustrated by these views generated by Mentor Graphics' System-1076 architectural editor.*

All digital ASICs designed after September 30, 1988, that are used to fulfill defense contracts will be documented using behavioral and structural VHDL descriptions.

to regain control over the difficult task of purchasing digital hardware. Everyone in the defense industry expects to see the DoD rely more and more heavily on VHDL for specifying subsystems and systems as engineers become more familiar with the language.

Some engineers have a bad attitude about VHDL because the language was developed under the DoD's VHSIC program and because you must use it to document the design of all ASICs incorporated into defense-related projects. Some designers even view VHDL as a potential obstacle to the design process because, like any engineering tool, you can intelligently use the language as a design aid or create roadblocks by misusing it.

Today, most engineers developing commercial and industrial products are blissfully ignorant of VHDL, and the absence of VHDL capabilities in most of the currently available EDA tools encourages this situation. Despite this state of affairs, VHDL has already moved to the center stage for all EDA tool development. In fact, attendees of the 26th Design Automation Conference, to be held this coming June 25 to 29 in Las Vegas, will see and hear about little else but VHDL.

As an industry standard, VHDL makes it much easier to build mutually compatible development tools. As a result, EDA-tool vendors strongly support VHDL because a standard hardware-description language can unify and broaden the market for their products. Of the hundred or so proprietary, public, and commercial hardware-description languages, most software developers flatly state that VHDL is the only industry-standard HDL. In addition, its rich array of features assure that VHDL can describe digital systems of any complexity. Thus, there is little impetus to develop "improved" digital hardware-description languages. VHDL is the US government's gift to the electronics industry.

The heart of VHDL is the language itself. VHDL statements let you create structural, data-flow, and behavioral design descriptions (see **box,** "A quick introduction to VHDL"). You can create modules that state functional capabilities without describing the underlying structure of that module. Or you can employ the language to describe structure alone, essentially creating a net list using the VHDL format.

You can verify your design through simulation using behavioral module descriptions before embarking on the detailed design of the modules. Thus, you can validate your design at the architectural design stage—far sooner than would be possible if you had to design every circuit before running simulations. VHDL also lets you create and simulate gate-level descriptions of the same circuit, so you can prove that your detailed design operates according to your architectural specification. This descriptive flexibility and power is quickly making VHDL a unifying force in the creation of EDA tools.

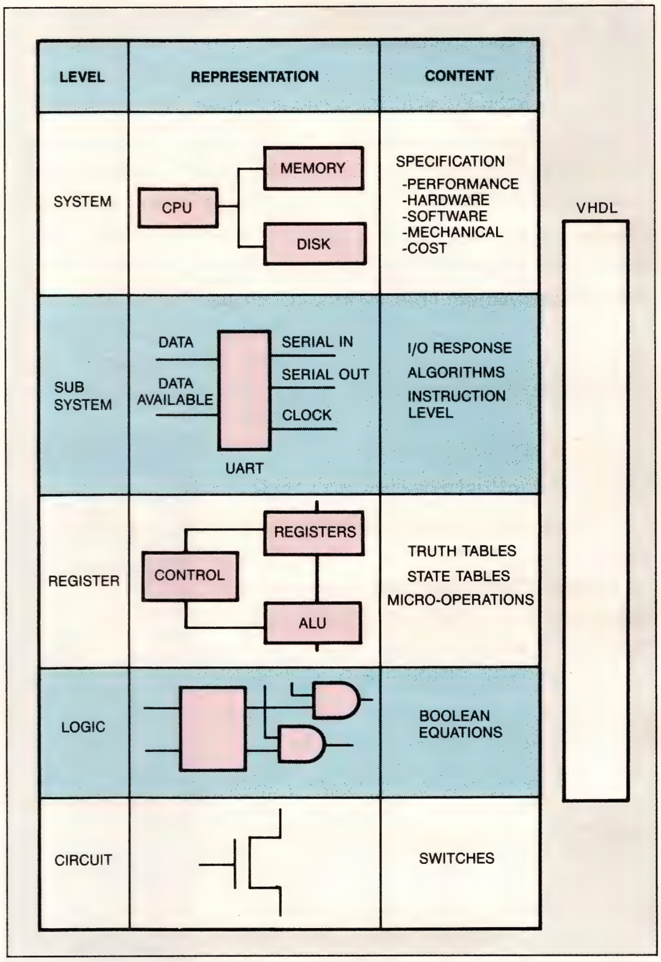


***Fig 1—VHDL statements can express** a range of design abstractions from the system to the gate level. The only design representation you cannot express in VHDL is the circuit level.*

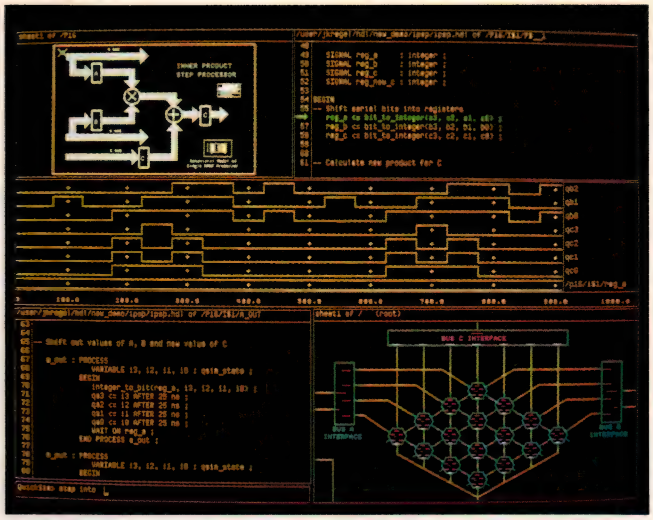
If VHDL's heart is the language, its soul is the simulator. Simulation capabilities give VHDL its real power, and VHDL simulators are among the most capable in the business because they must accommodate a wide range of abstraction, from the architectural level to the gate level (**Fig 1**). You should note that VHDL cannot describe or simulate circuits at the switch or transistor level, so low-level simulators for ASIC de-

signs will not yet be replaced by VHDL simulators. This dichotomy allows VHDL to be independent of any semiconductor technology and allows ASIC vendors to keep their proprietary, process-specific characteristics a secret.

Intermetrics produced the first VHDL development tools by creating an analyzer and a simulator under a DoD VHSIC contract. The VHDL analyzer checks your VHDL source document for proper syntax and converts the description to an intermediate format. The simulator exercises your design using this intermediate-format description.

That first version of VHDL, finalized as version 7.2, attained the goals set forth in the VHSIC program but did not achieve industry acceptance as a universal hardware-description language because the language was incomplete. The IEEE assumed the task of polishing VHDL and developed a standard language that EDA tool vendors and users could really use. VHDL officially became IEEE-1076 in December, 1987.

Intermetrics subsequently rewrote its VHDL tools and made them compatible with the IEEE-1076 specifications. The company licenses its tools on a monthly basis and teaches several classes in the use of VHDL and the Intermetrics VHDL tool set. The classes cost from \$3000 to \$8500. The Intermetrics VHDL Design Environment runs on a Digital Equipment Corp VAX minicomputer and costs \$1500 per month if you receive training and \$2000 per month if you don't receive training. The product includes a VHDL analyzer, an interactive simulator, and a library system that maintains your design database (**Fig 2**). The company is willing to enter into agreements with other VHDL-tool vendors that want to incorporate the VHDL Design Environment into their CAE products.



Though it is a text-based language, *VHDL works equally well with graphic design methods. In this 5-window view of a multiple-processor system, Mentor Graphics' System-1076 design tool displays the graphic and VHDL representations of one processor (top left and right, respectively), a graphic view of the multiprocessor system (lower right), and the simulator's waveform output (middle).*

The Intermetrics VHDL analyzer and simulator employ an intermediate format called IVAN (intermediate VHDL attributed notation). Like the intermediate formats employed by many HDLs, IVAN is a proprietary format. Thus, the Intermetrics analyzer and simulator are intended to work together as a pair and are closely coupled. CAD Language Systems Inc (CLSI) has taken a different approach to VHDL-tool development by offering a product designed to enable existing simulators to accept VHDL descriptions.

CLSI's \$15,000 VHDL Tool Integration Platform

Text continued on pg 116

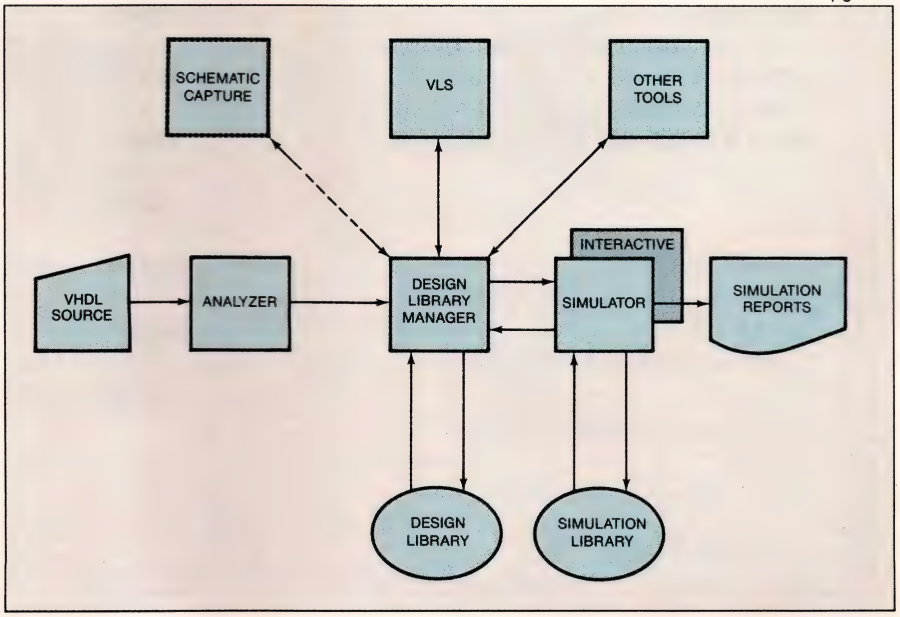


Fig 2—As the first VHDL tool set, *Intermetrics' Design Library System established some common modules, such as the VHDL analyzer and simulator.*

A quick introduction to VHDL

Like all hardware-description languages, VHDL serves two purposes: circuit description and simulation. You describe logic circuits in VHDL using the *design entity*, which can represent logic blocks of any complexity. To avoid overly long and complex entity constructions, VHDL permits hierarchical descriptions: An entity can refer to other entities.

Each entity consists of two types of descriptions: the interface description and the architectural body. An entity may contain only one interface description, which names the entity and lists the entity's input and output ports. But an entity may contain one or more architectural bodies, which specify the entity's behavior and structure. VHDL does not force you to specify either the behavior or the structure of a logic block.

Fig A shows a conventional, graphic representation of a simple logic circuit that generates the majority function of three inputs. The circuit's output will assume a logic 1 state if two or three of its inputs are set to 1. The Boolean equation for this circuit is

$$Z = X(0)*X(1) + X(0)*X(2) + X(1)*X(2).$$

The first three lines of **Listing 1** provide the VHDL interface description for this 3-bit majority-function circuit named MAJ3. The first line provides the entity's name. The second line designates the logic circuit's three input ports as an input bit vector named X with subscripts numbered 0, 1, and 2. This line also names a 1-bit output port: Z. The three inputs, X(1), X(2), and X(3), form a 3-bit input vector in this description, but they could have been described as three separate inputs named "Larry," "Moe," and "Curly" just as easily. Names and port configurations are selected at the designer's discretion.

The structural description of the majority-function circuit starts in the second part of **Listing 1** with the line containing the keyword *architecture*. This line

LISTING 1

```
entity MAJ3 is
 port (X: in BIT_VECTOR(0 to 2); Z: out BIT);
end MAJ3;

architecture STRUCTURE of MAJ3 is

 component AND2
    port (I1, I2: in BIT; O: out BIT);
 component OR3
    port (I1, I2, I3: in BIT; O: out BIT);
 signal A1, A2, A3: BIT;

begin

 G1: AND2
    port map (X(0), X(1), A1);
 G2: AND2
    port map (X(0), X(2), A2);
 G3: AND2
    port map (X(1), X(2), A3);
 G4: OR3
    port map (A1, A2, A3, Z);

end STRUCTURE;
```

LISTING 2

```
entity AND2 is
    port (I1, I2: in BIT; O out BIT);
end AND2;

architecture BEHAVIOR of AND2 is

begin
    O <= I1 and I2;
end BEHAVIOR;

entity OR3 is
    port (I1, I2, I3: in BIT; O: out BIT);
end OR3;

architecture BEHAVIOR of OR3 is

begin
    O <= I1 or I2 or I3;
end BEHAVIOR;
```

designates the following section of code as an architectural body. The next four lines declare the two components AND2 and OR3—a 2-input AND gate and a 3-input OR gate—that will be used in the circuit. The architectural body also names the inputs and outputs of these elements. The fifth line contains the keyword *signal* and names the three internal signals, A1, A2, and A3, contained within the design.

The actual description of the circuit's structure appears between the keywords *begin* and *end.* This portion of the architectural body, named STRUCTURE, instantiates four components using the general AND and OR gates named at the beginning of the architectural body. Each instantiation has a label (G1, G2, G3, and G4) and a port map that names the signals to be connected to each component's input and output ports. In this example, signal names in these instantiations are associated with component ports by position. So for the instantiation of the 2-input AND gate labeled G1, inputs I1 and I2 are associated with signals X(0) and X(1), respectively, and output O is associated with internal signal A1. VHDL also lets you associate signals with ports by name.

The VHDL structural description is nothing more than a net list that states how components within a logic block are interconnected. Because of VHDL's hierarchical nature, you can assemble very complex structures using relatively simple architectural bodies. Though net lists have been commonly used for years, VHDL provides a standard netlist format. Thus, a simple use of VHDL is as a standard format for passing net lists between EDA tools.

Listing 2 describes the behavior of the two component types used in the majority-function circuit. In this description, each component has its own entity with an architectural body that describes that entity's behavior. These behavioral descriptions, coupled with the structural description of the entire logic block, provide a VHDL simulator with sufficient information to compute the circuit's response to varied inputs. This simple tutorial ignores such realities as the time delay through each gate, but rest assured that VHDL can describe those parameters as well.

At first glance, these lengthy VHDL descriptions seem to have little advantage over the well-understood graphic depiction of the circuit in **Fig A.** Indeed, for simple examples such as the one in this tutorial, graphic symbols are much easier for a person to understand. However, the true power of VHDL lies in its hierarchical ability to describe complex systems using the simplest building blocks and in its suitability as a simulation language. Unlike conventional schematic symbols, VHDL descriptions can accurately describe the function of a logic block, even before the block's gate- or component-level design is known. Thus, VHDL descriptions are well targeted for the simulation of digital systems at the earliest stages of architectural design and throughout the design process.

(Note: This introduction to VHDL was adapted from chapter 2 of Dr James R Armstrong's book, *Chip-Level Modeling with VHDL* (**Ref 2**).)

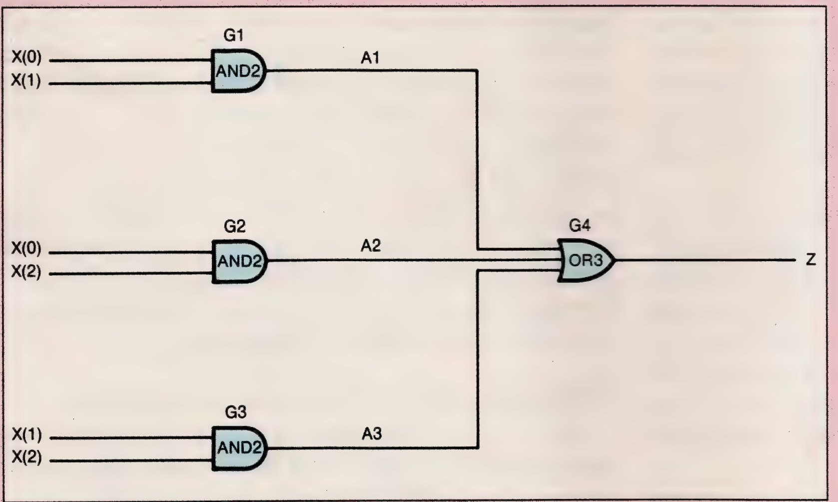


Fig A—You can easily recognize the functional capabilities *of a simple logic block, such as this 3-input majority-function circuit, from a graphic diagram. However, VHDL descriptions make circuitry easily intelligible to EDA tools and are better suited for large, complex chip or system descriptions.*

Like any engineering tool, you can intelligently use VHDL as a design aid or create roadblocks by misusing it.

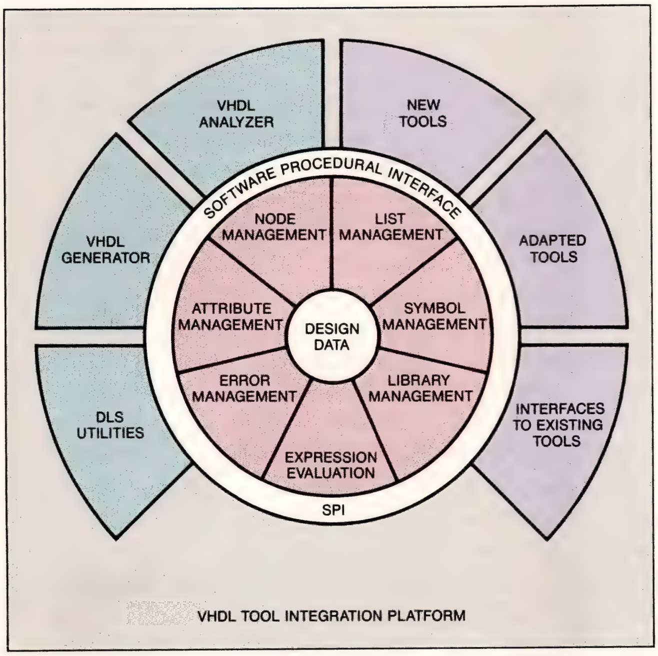


***Fig 3—Because it serves as a link** between VHDL and non-VHDL EDA tools, the VHDL Tool Integration Platform (VTIP) includes a VHDL analyzer but no simulator. Among its other uses, the VTIP enables existing simulators to accept VHDL descriptions.*

(VTIP) includes a context-sensitive editor for creating VHDL descriptions, an analyzer that verifies the syntax of VHDL source code and transforms VHDL descriptions into an intermediate format, a generator that regenerates the VHDL source code from the intermediate format, and a Design Library System (DLS) librarian that maintains the intermediate-format structures in a database **(Fig 3)**. The company has proposed the use of its DLS as a standard intermediate format to the IEEE's VHDL Intermediate Form Analysis and Standardization Group.

CLSI provides a set of utility programs it calls the Software Procedural Interface (SPI) for obtaining access to information stored in the DLS. Thus, vendors of existing simulators can use CLSI's DLS as a link between their simulator and VHDL by writing an interface program that links the simulator to the DLS through the SPI. CLSI has already contracted to provide VHDL capabilities to GenRad's widely used HiLo simulator in this manner.

GenRad sells HiLo packages for several computers with prices that start at approximately $15,000, and several EDA software vendors incorporate the HiLo simulator into their design tools. CLSI is linking HiLo to VHDL by translating from source documents written in a subset of VHDL to HiLo's GHDL (GenRad Hardware Description Language). GHDL can only handle a subset of VHDL's statements because the capabilities of the two HDLs do not completely overlap. VHDL has some attributes of high-level software programming languages—such as certain data types (enumerations, real numbers, integers, and records), procedure calls, and loops—that do not map into GHDL features. However, HiLo's fault- and analog-simulation capabilites continue to make that product valuable, even with the advent of VHDL, because VHDL does not yet have these features. Thus, GenRad and its customers have strong reasons to want a translator.

Compatibility through translation

Similarly, Gateway Design Automation intends to make its simulation products compatible with VHDL. Gateway's $25,000 Verilog and $35,000 Verilog-XL HDL and simulation packages currently enjoy what the company claims is the largest installed base of any HDL. However, recognizing the importance of VHDL to the design community, the company has announced a plan to enable Verilog users to write descriptions with VHDL as well. In light of the DoD mandate to use VHDL for documenting all ASICs supplied under defense contracts, that's a very reasonable move. Gateway's plan for incorporating VHDL into its product line involves three steps, as shown in **Fig 4.**

The first step in Gateway's plan calls for the creation of a translator that will generate VHDL descriptions from Verilog's intermediate form. This step allows Verilog users to comply with the DoD's current documentation requirements for ASIC designs. Step 2 involves enhancing the Verilog simulator so that it accepts descriptions written in a subset of the full VDHL, thus giving Verilog users the choice between writing descriptions in Verilog or VHDL. Many industry observers believe that the DoD will eventually require that you *develop* ASICs in VHDL. Thus, in the final evolutionary step, Gateway will extend Verilog to accommodate the entire IEEE-1076 language.

VHDL supports graphic design methods too

Although you can create hardware designs by writing pages and pages of VHDL code that you then submit to a VHDL analyzer and simulator, the language supports a variety of other design methods as well. Vantage Analysis Systems offers a $44,000 software package called the VantageSpreadsheet that enables Mentor Graphics' existing design system to gen-

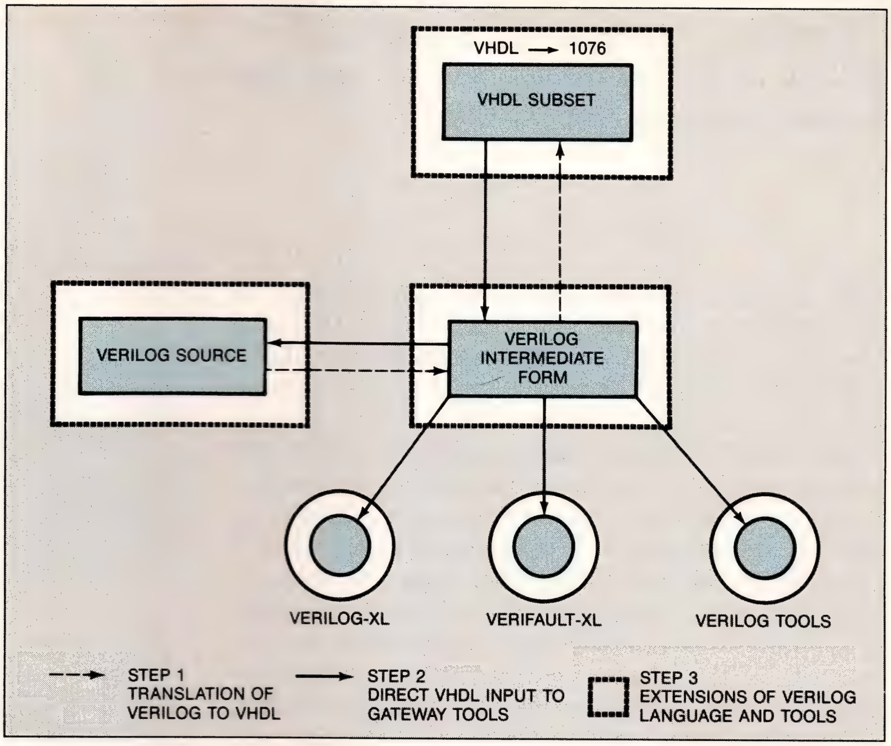


***Fig 4—This 3-step process** will allow Gateway Design Automation to make its Verilog products fully compatible with VHDL.*

erate VHDL code. The VantageSpreadsheet accepts Mentor's NETED schematic files and converts the design data into VHDL code **(Fig 5)**. In addition, the VantageSpreadsheet can accept designs written in VHDL and includes a VHDL simulator to test the designs.

Vantage's product provides you with several screen windows, so you can see different views of your design simultaneously. For example, you can display schematic and VHDL-text representations of your design at the same time that you're observing the progress of a simulation in a waveform window. You can modify the schematic design using the VantageSpreadsheet's schematic viewer, and your changes will be reflected by the waveforms in the simulation window within seconds because of the tight coupling between the schematic viewer and the simulator. In fact, this rapid response time is why Vantage selected the spreadsheet nomenclature.

The company asserts that its simulator's rapid response to circuit changes made with the schematic viewer lets you play "what-if" games with your design in the same manner that conventional spreadsheets, such as Lotus Development's 1-2-3, let you investigate alternative financial strategies. Vantage's claim seems quite valid, especially if you compare the process of developing VHDL descriptions to that of writing software code. Both tasks divert you from the job at hand—creating and debugging your design—and force you into a time-consuming cycle of editing, compiling (or analyzing), running (or simulating), and debugging. The schematic viewer simplifies this cycle: Make a change to the schematic and immediately see the results with no further action. When you're satisfied with your design, the schematic viewer lets you make your changes permanent through a back-annotation feature that modifies the original NETED file.

While Vantage's product lets you add VHDL capabilities to existing Mentor Graphics design systems, Mentor has announced that it will add VHDL capabilities to its own products in the form of System-1076. The VHDL portion of this product works in concert

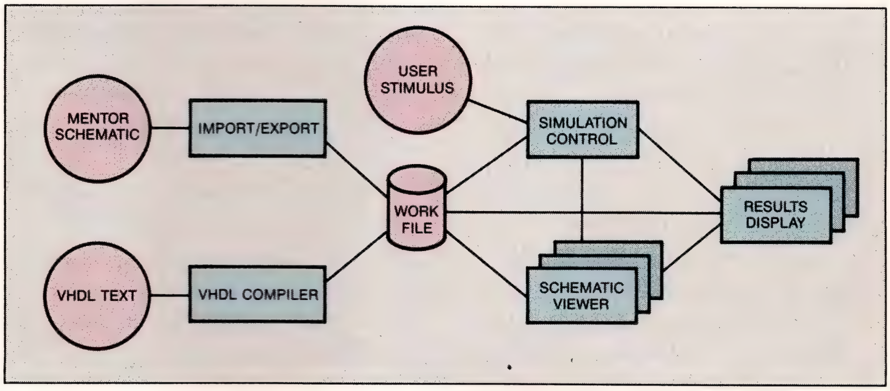


***Fig 5—By closely integrating its schematic viewer** with its VHDL simulator, Vantage Analysis Systems produced the VantageSpreadsheet, which can display the results of a design change made during a simulation moments after the change is made.*

Attendees of the 26th Design Automation Conference, to be held this coming June 25 to 29 in Las Vegas, will see and hear about little else but VHDL.

with Mentor's existing design and analysis tools, so you can develop portions of a design using VHDL and the rest of the design with other methods **(Fig 6)**.

Mentor enhanced the capabilities of its existing Quicksim simulator to accommodate VHDL descriptions and models rather than changing to an all-VHDL simulator so that Quicksim could maintain compatibility with circuits designed prior to the introduction of the VHDL extensions. The company states that it chose to expand Quicksim rather than translate between VHDL and some other format because the translation process can introduce uncertainty concerning the integrity of the source code and because translators complicate the debugging process. System-1076 will be available in the third quarter of 1989; prices will start at $24,900.

Mentor plans to add an architectural editor to System-1076 in 1990. Using this editor, you will be able to create graphical, architectural-level descriptions of your design and generate VHDL source code from these graphical descriptions. Mentor's VHDL simulator can then simulate this architectural description, thus giving you a look at your system's performance before you embark on a detailed design.

If you're not satisfied with the performance of your architecture, you can make the needed changes before

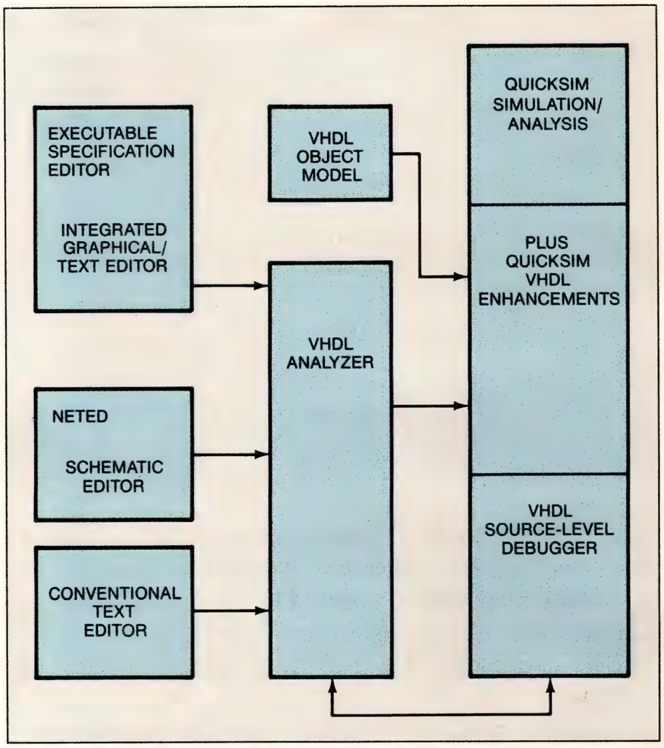


***Fig 6—Enhancements to its existing** Quicksim simulator allowed Mentor Graphics to integrate VHDL capabilities into the company's existing design tools.*

VHDL needs a few good models

VHDL's simulation capabilities are what make the language so valuable to EDA-tool vendors and users. As with any simulation language, VHDL users need large libraries of simulation models to make the language truly useful. One of the reasons that pre-VHDL simulators have not become more widespread is the proprietary nature of existing simulation models. In the past, models created for one simulator rarely worked with more than that particular simulator.

In theory, standard VHDL-based models will work on any VHDL simulator. Both the EIA (Electronic Industries Association) and the IEEE are sponsoring committees that are cooperatively working on VHDL model standards so that simulator and model vendors can realize the theoretical universality of VHDL models. A modeling standard would ensure a ready supply of models for the latest parts and should keep the price of simulation models reasonable by increasing the potential size of the market.

The EIA committee, chaired by M J Willner of Hughes Aircraft Co, includes members from five key groups: the US government, semiconductor vendors, the VHDL user community, simulation-modeling and CAE companies, and simulator vendors. In addition, the EIA is currently holding discussions with both the US government and major US electronics companies about a joint venture to create some 200 standard VHDL models for the most commonly used standard VLSI devices. For more information on these standardization efforts, contact

EIA
2001 Eye St NW
Washington, DC 20006
(202) 457-4900.

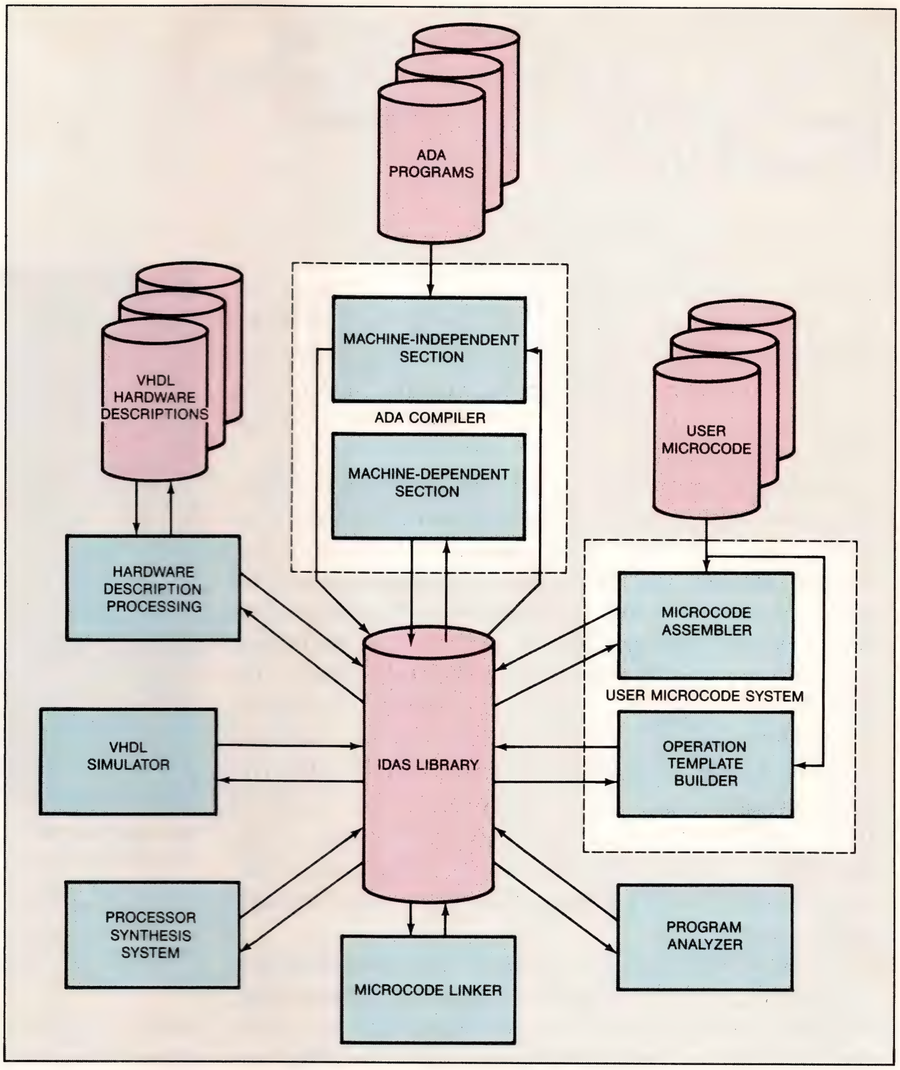


Fig 7—By combining the VHDL and Ada languages, *JRS Research Laboratories created IDAS, a tool that can synthesize a processor architecture that is optimized for a specific Ada program.*

spending time on a detailed circuit design. When you're satisfied that your design will meet your requirements, you can start developing the specifics by replacing the architectural descriptions with circuit descriptions, module by module, until the design is complete. Because VHDL lets you mix models at different architectural and hierarchical levels, you can run simulations throughout the design process to verify that your design is continuing to meet specifications.

VHDL encourages experimentation

Because of its ability to describe and model systems at different levels of abstraction, VHDL is already allowing software vendors to develop new types of hardware-design tools. For example, IDAS (Integrated Design Automation System) from JRS Research Labs accepts Ada source code and VHDL component models. The system synthesizes an optimized processor design plus the microcode required to run the submitted Ada program (**Fig 7**).

You can use IDAS to compile an Ada program into microcode for a processor design that you specify in VHDL, or you can use the system to synthesize an optimal processor design based on your Ada program and logic blocks expressed in VHDL. IDAS emits these synthesized hardware designs in VHDL. Thus, IDAS can help you evaluate several software algorithms and alternative processor architectures, so that you can quickly and objectively select the optimum solution for your application. IDAS costs $200,000 and requires a network of one or more DEC VAX minicomputers and one or more IBM PC or compatible computers that serve as development workstations.

As an example of VHDL's flexibility, a design tool from Ilogix called Statemate implements a design technique that was created for developing the avionics in Israel's Lavi fighter-aircraft project. The product lets you develop and test state machines using a graphical approach. The Statemate system consists of four parts: a kernel, which contains three graphic editors for entering your design in the form of state diagrams; an analyzer for simulating the designs; a prototyper, which automatically generates code from the state diagrams; and a documentor for creating text descriptions of the design from the state diagrams. The Statemate kernel, analyzer, prototyper, and documentor cost $10,000, $25,000, $25,000, and $15,000, respectively.

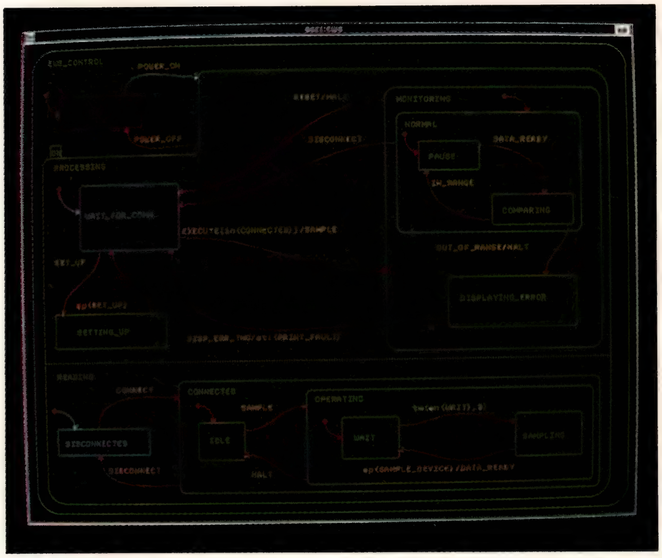
Although Statemate currently emits Ada source

Of the hundred or so proprietary, public, and commercial hardware-description languages, most software developers flatly state that VHDL is the only industry-standard HDL.

code, the product's graphic design format lets you specify the concurrency, timing, and sequencing of state-machine components. Because these attributes are just as easy to describe in VHDL as they are in Ada, the company plans to introduce a version that produces VHDL code this year.

Another product that lets you design at the architectural level using graphic representations is ADAS (Architecture Design and Assessment System) from Research Triangle Institute (RTI). You use the ADAS graphic editor to create software data-flow and hardware-configuration graphs that represent your design. You can then map the software algorithms (processes) onto hardware-graph nodes (processors) to evaluate the performance of a system. Once you are satisfied with the result, ADAS can produce a VHDL description of your design. Cadre Technologies has acquired all marketing rights to the $35,000 ADAS package and has paired the product with its own Teamwork software-design system for integrating hardware and software development.

RTI used VHDL to link ADAS to the Genesil silicon compiler from Silicon Compiler Systems. Using ADAS, RTI developed the design of a 16,000-transistor, edge-detection IC for imaging applications. The chip employs the Sobel edge-detection algorithm. Once the design was complete, RTI transferred the description of the chip to the Genesil compiler through a VHSIC silicon compiler interface. The compiler then synthesized the chip's layout. This project, sponsored by the US Air Force, demonstrates that VHDL descriptions can be used as an input language for layout tools, even though the language does not model circuits at the transistor level. Other companies that are developing VHDL enhancements to their IC-layout products include Harris Semiconductor, Seattle Silicon, and Synopsis.



As a standard hardware-description language, *VHDL lets you employ many alternative design methods, such as this graphic, state-diagram approach implemented by the Ilogix Statemate design tool. As long as all of your design tools emit VHDL source code, you can easily integrate pieces of a system created with different methods into one source document with nothing more than a text editor.*

The VHDL Users' Group

Because of the major impact VHDL is already having on EDA tools and because of the many usage issues that require resolution, tool vendors and users have banded together to form the VHDL Users' Group. The group assists members through educational activities, communications with the various VHDL standardization committees meeting around the country, and regular users' group meetings. The next VHDL Users' Group meeting will be June 22 to 23, 1989, in Washington, DC. For more information, contact

VHDL Users' Group
127 Beaumont Ave
San Francisco, CA 94118
(415) 387-8262

Extending VHDL beyond hardware design

VHDL's capabilities reach beyond hardware design. You can use it as a concise, unambiguous language for creating system specifications well before initiating the actual system design. As EDN previously noted in a Special Report on ASIC simulators, no simulator in existence can make up for the failure to properly specify a design (**Ref 1**). You can use VHDL descriptions as part of your project's specification phase to create a precise document that will mimic the actual product's performance during simulation.

A recently concluded study sponsored by the NSIA (National Security Industrial Association) used VHDL as a system-specification and -acquisition tool for digital hardware by modeling a hospital telemetry system with it. The proposed system monitors as many as four patients with as many as eight instruments per

Although you can create hardware designs by writing pages and pages of VHDL code, the language supports a variety of other design methods as well.

patient. Though the study team verified that such a specification could provide sufficient information to generate a complete proposal, it also concluded that the VHDL tools available in 1988 were still fairly primitive and, therefore, somewhat difficult to use.

Because stacks of paper specifications do not provide ready insight into the inner workings of a complex design, the NSIA study recommends that VHDL de-

Manufacturers of VHDL-based EDA tools

For more information on VHDL-based EDA tools such as those described in this article, contact the following manufacturers directly, circle the appropriate numbers on the Information Retrieval Service card, or use EDN's Express Request service.

CAD Language Systems Inc
51 Monroe St, Suite 606
Rockville, MD 20850
(301) 424-9445
Circle No 656

Cadence
555 River Oaks Parkway
San Jose, CA 95134
(408) 943-1234
Circle No 657

Cadre Technologies Inc
222 Richmond St
Providence, RI 02903
(401) 351-5950
FAX 401-351-7380
Circle No 658

Daisy Systems Corp
Box 7006
Mountain View, CA 94039
(415) 960-0123
Circle No 659

EIS Modeling Inc
2483 Old Middlefield Way
Mountain View, CA 94043
(415) 964-2296
Circle No 660

Gateway Design Automation Corp
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Lowell, MA 01852
(508) 458-1900
FAX 508-441-1109
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Genrad Inc
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Concord, MA 01742
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Logic Modeling Systems Inc
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FAX 503-626-1202
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Research Triangle Institute
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Research Triangle Park, NC 27709
(919) 541-7436
Circle No 673

Seattle Silicon Corp
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Belleview, WA 98004
(206) 828-4422
FAX 206-827-4224
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Silc Technologies Inc
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Burlington, MA 01803
(617) 273-1144
FAX 617-229-8174
Circle No 675

Silicon Compiler Systems Corp
2045 Hamilton Ave
San Jose, CA 95125
(408) 371-2900
Circle No 676

Silvar Lisco
1080 Mersh Rd
Menlo Park, CA 94025
(415) 324-0700
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Synopsis Inc
1500 Salado Dr
Mountain View, CA 94043
(415) 962-5000
FAX 415-965-8637
Circle No 678

Teradyne EDA
5155 Old Ironsides Dr
Santa Clara, CA 95054
(408) 980-5200
FAX 408-748-7761
Circle No 679

Trimeter Technologies Corp
200 Hightower Blvd, Suite 100
Pittsburgh, PA 15205
(412) 787-8630
Circle No 680

Valid Logic Systems Inc
2820 Orchard Pkwy
San Jose, CA 95134
(408) 432-9400
Circle No 681

Vantage Analysis Systems Inc
42840 Christy St
Fremont, CA 95438
(415) 659-0901
FAX 415-659-0129
Circle No 682

Viewlogic Systems Inc
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Marlboro, MA 07152
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FAX 508-480-0882
TLX 17424
Circle No 683

Vista Technologies Inc
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Circle No 684

VLSI Technology Inc
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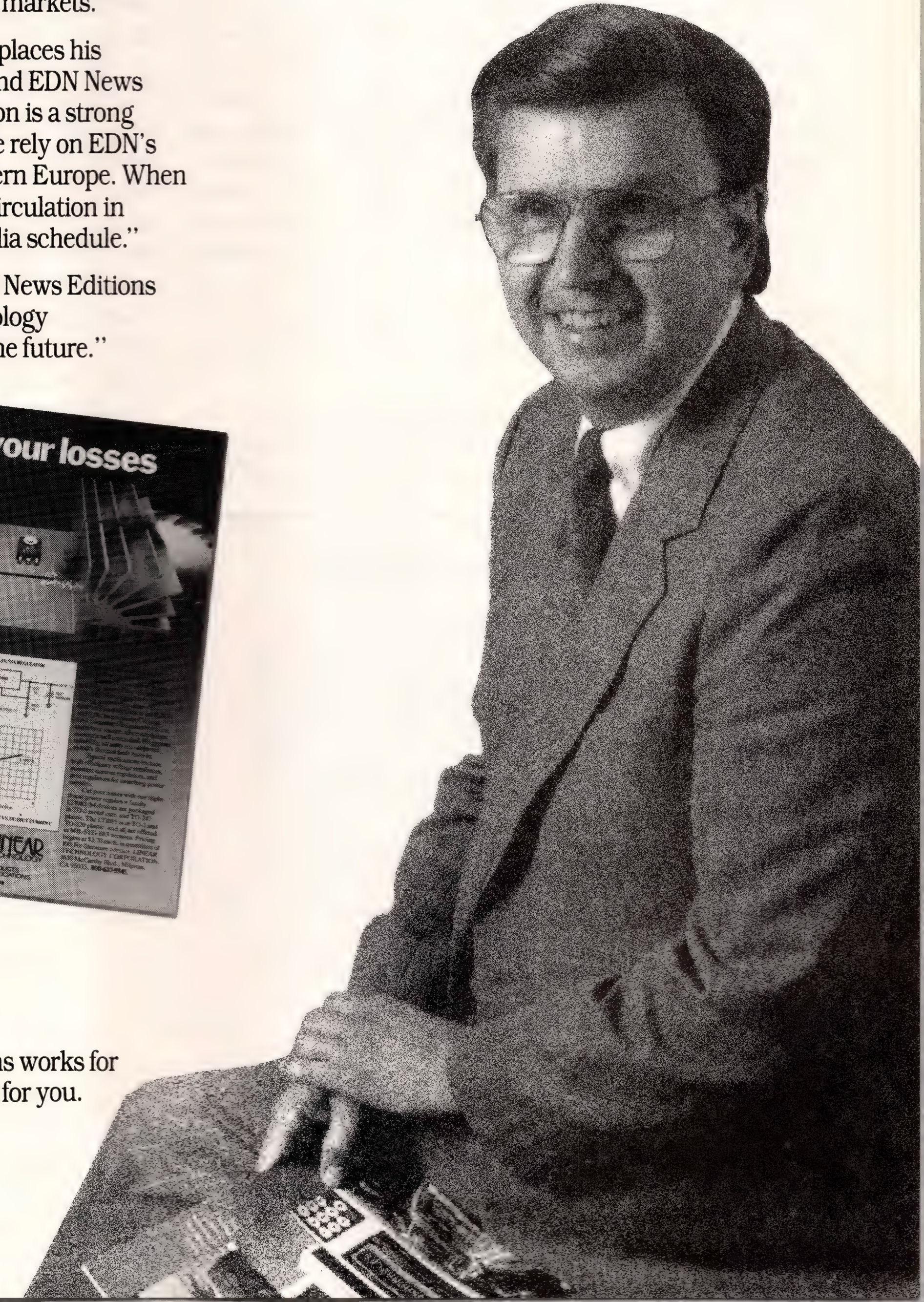

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VHDL is already allowing software vendors to develop entirely new types of hardware-design tools.

scriptions be incorporated into requests for proposals (RFPs). These descriptions would provide a working document that would aid the reprocurement, maintenance, support, and reuse of digital systems acquired by the government. You don't need to stretch your imagination to see that these same benefits would apply to commercial and industrial projects as well.

With this study, the NSIA lays the foundation for the incorporation of VHDL specifications into DoD RFPs. By simulating a VHDL-based RFP document, companies interested in bidding on such contracts could get a much more precise feel for what sort of system is desired than they could with a conventional paper document. In addition, bidders can submit proposals that include VHDL architectural models of contemplated system architectures. The DoD can run these proposals through a simulator to get a much better feel for the actual performance of a proposed system. Throughout the development cycle, VHDL descriptions can capture the intent of a design as well as its structure and can be used to document design tradeoffs as well.

NSIA's clear purpose in sponsoring this study was nothing less than a bold transformation of the current DoD acquisition policies into a more objective and certainly more accurate process. The use of VHDL descriptions in RFPs and proposals also increases the likelihood that a contractor can transform a proposal into a real product that both works and meets the buyer's and seller's specifications.

VHDL: the common denominator for EDA tools

If you take a last look at the disparate products represented in **Figs 1** through **7**, you'll see that the common element is VHDL. Like a planet with a powerful gravitational field, VHDL is drawing the full range of electronic-design-automation tools into its orbit. Currently, EDA products that incorporate VHDL run primarily on minicomputers and engineering workstations from vendors such as Apollo and Sun Microsystems. As a consequence, the first VHDL-based products are rather expensive. You should recall, however, that the same situation existed a few years ago when software vendors introduced the first Ada compilers. Today you can buy Ada compilers for PCs for less than $100. As the EDA market matures, expect VHDL to similarly diffuse into lower-cost, PC-based, hardware-design tools. EDN

An analog future for VHDL?

IEEE-1076 lacks the ability to describe and model the full spectrum of electronic system designs because it's limited to digital circuitry. Try as they might, engineers can't seem to eliminate analog circuitry from many systems and ASICs, so VHDL can only describe the digital portions of these designs today. An IEEE committee is developing a set of requirements for an analog hardware description language (AHDL) that could evolve into a companion language or result in extensions that would add analog-description capabilities to VHDL. For more information about the AHDL effort, contact

Dr Joel Schoen
Mitre Corp
Bedford, MA, 01730
(617) 271-2230

References

1. Conner, Margery S, "ASIC simulators," *EDN*, February 4, 1988, pg 119.
2. Armstrong, James R, *Chip-Level Modeling with VHDL*, Prentice Hall, Englewood Cliffs, NJ, 1989.

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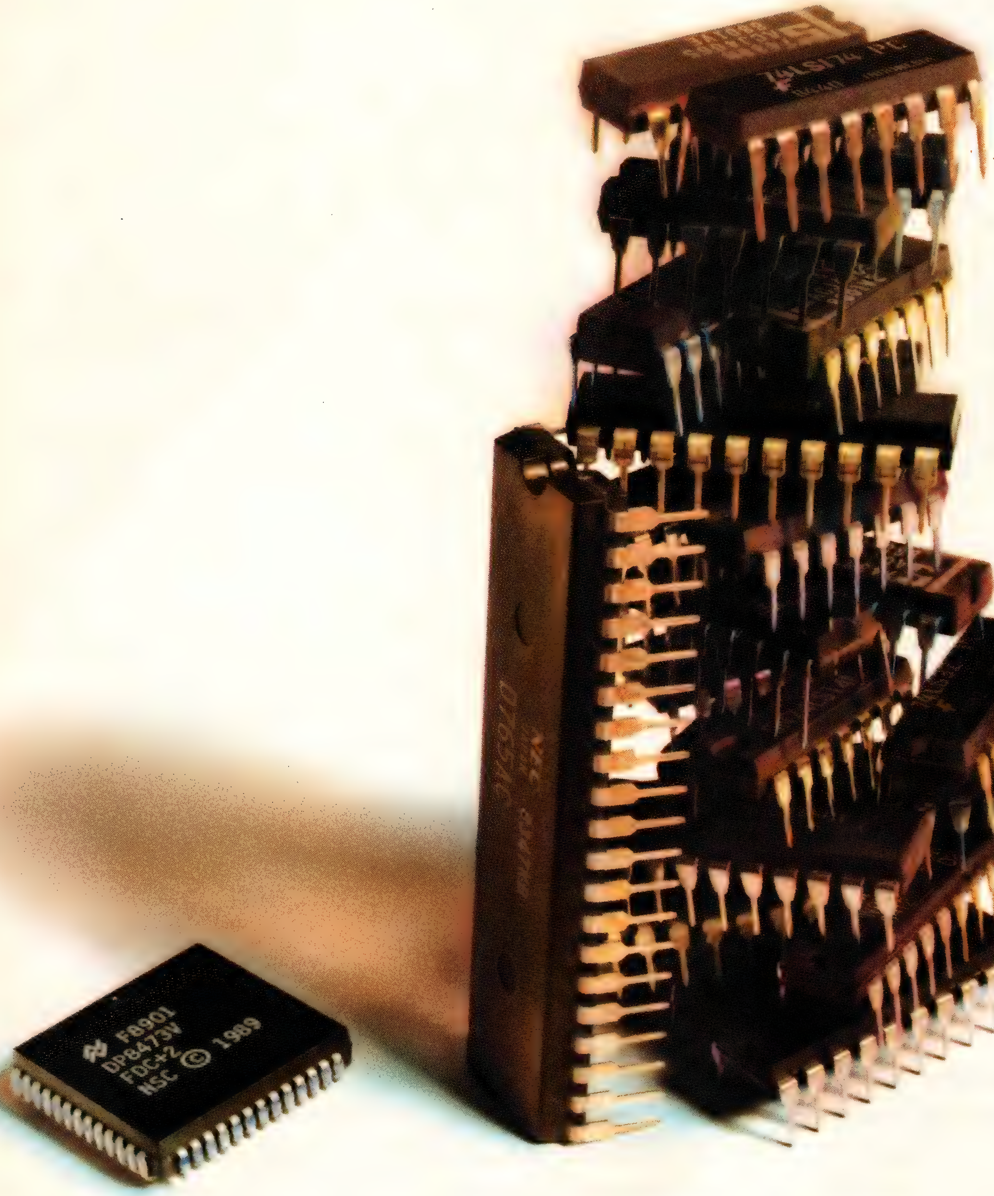

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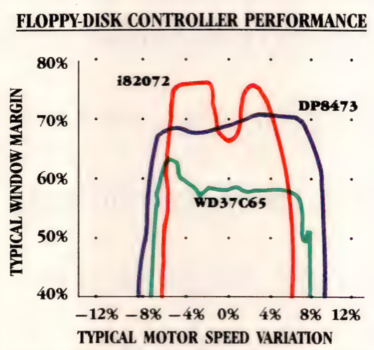

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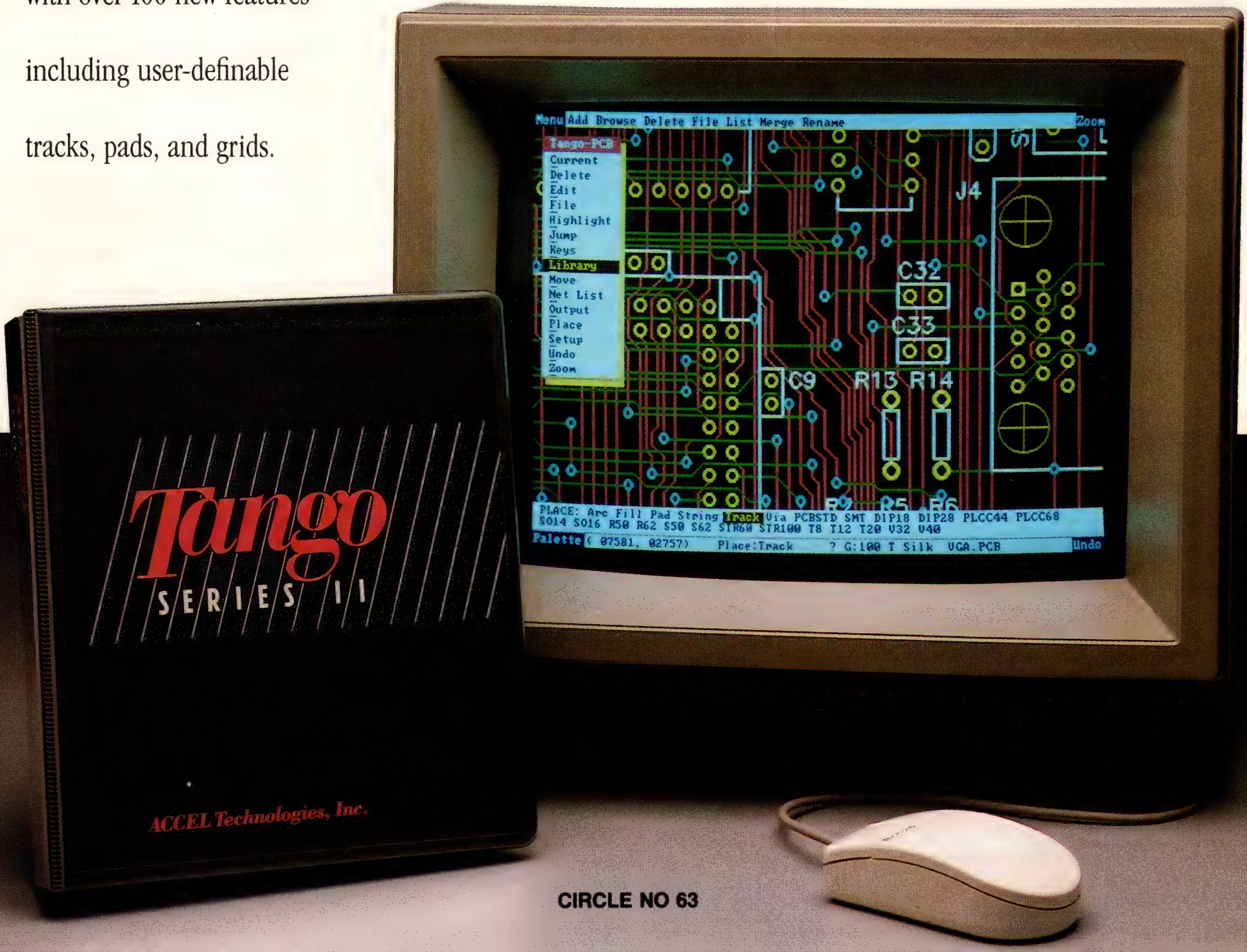

CIRCLE NO 63

Construct a low-cost 8096-family development system

Software engineers are often reluctant to abandon their familiar software-based debugging techniques. But when doing cross development, they often have no choice because the software they're developing won't run on the host system. Development hardware lets engineers extend their debugging expertise into the hardware domain.

Eric P Horton, *Dedicated Computer Systems*

The single-chip-μP board in **Fig 1** can help you develop 8096-family single-chip-μP projects in two ways. First, it functions as an execution environment for testing software. With the board, you can debug your software using hardware-based debugging facilities that are similar in application to common software-debugging techniques. Second, the board can serve as a simple 8096-family in-circuit emulator for debugging your target system's hardware. Despite this broad range of applications, the single-chip-μP board uses only a few, inexpensive components and is simple to build.

The **box,** "Programs, pc board, and PLD available" gives the source of the EPROM-based monitor for the single-chip-μP board along with debugging software that runs on an IBM PC. The monitor program, single-chip-μP board, and IBM PC software—when combined with your cross compiler or cross assembler—form a workable software-development system.

As an in-circuit emulator, the board's hardware makes several compromises with perfect emulation to minimize costs and make use of only commonly available ICs. And the onboard monitor must compromise emulation to a certain degree because it uses some code space and processor facilities. In return for these facilities, the monitor provides debugging aids such as serial communication, software breakpoints, single stepping, and single-chip-μP register reports.

As an emulator, the board does not usurp any of the single-chip-μP's pins; all of the μP's pins are emulated and available for your use. For example, although some other 8096 single-chip-μP boards require the non-maskable interrupt pin (NMI), the monitor in this board does not. Some of the single-chip μP's pins are buffered, however. Generally, you do not need exact pin-for-pin emulation for single-chip-μP development. In particular, the emulator uses RAM for both program and data storage. You'll find that splitting the final code between EPROM for code storage and RAM for data storage in the target system is usually straightforward and bug free.

The monitor affects none of the single-chip μP's internal data registers or special-function registers and temporarily uses only six stack locations.

The software execution environment

You can test embedded-control application programs for single-chip μPs without the complex debugging facilities, such as deep trace files, provided by more ex-

Generally, you do not need exact pin-for-pin emulation for single-chip-μP development.

pensive emulators if you confine your efforts to well-structured programs. By using a top-down approach, your program's flow should be predictable and, therefore, easy to test and debug. Avoid complex schemes such as re-entrant code.

The BH versions of the 8096 family, the 80C196 and 8098, are used with this board. These devices have an 8-bit external, multiplexed address/data bus but retain 16-bit buses for internal operation. Although this single-chip-μP board does entail a few compromises, you should find the final transition from prototype development to the actual target system effortless and uneventful.

Looking at the map

Within the memory map for this board (**Fig 2**), the monitor program's EPROM space is 8k bytes and begins at address location 2000_{HEX}. The monitor program is only 3k bytes, and the remaining 5k bytes are available for other uses.

Note that unlike previous single-chip μPs from Intel, the 8096 does not reset to 0000_{HEX}. Instead, the inter-

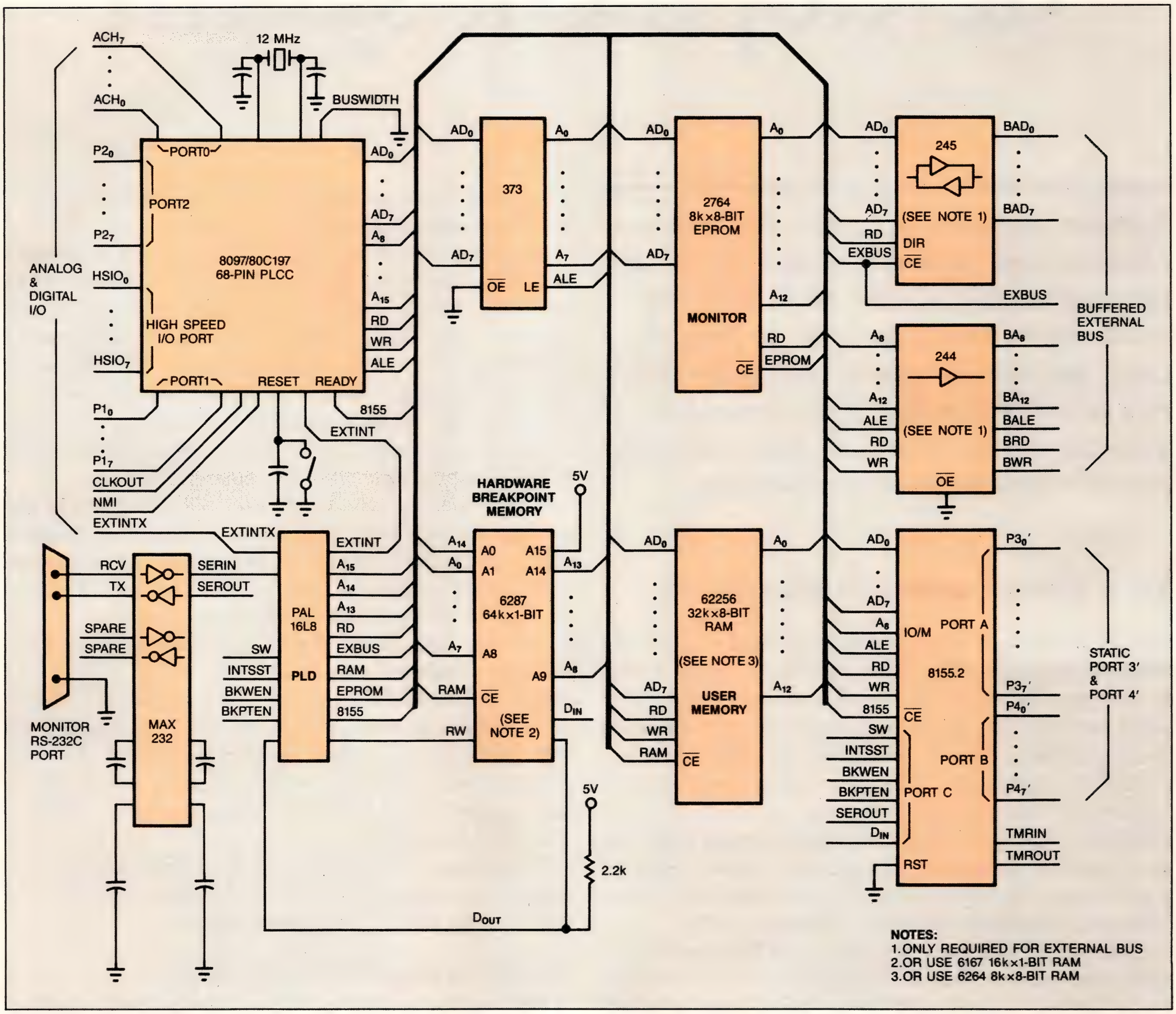

***Fig 1—This 8096-family, single-chip-μP** board can function both as a software-execution environment for trying out programs and as an in-circuit emulator.*

rupt vectors and other initialization values must begin at 2000_{HEX}. Upon reset, this single-chip µP begins processing at memory location 2080_{HEX}.

The 8155 device **(Fig 1)** has both hardware and software functions. Along with some I/O devices, it contains 256 bytes of RAM. The RAM resides in the lower 8k bytes of system memory beginning at 0000_{HEX}. The monitor uses 16 bytes at the top of the 8155's RAM for temporary data storage; you can use the remaining 240 bytes for either program code or data. For example, your nonmaskable-interrupt (NMI) routine could reside in this leftover RAM beginning at 0000_{HEX}.

Your user-program RAM normally begins at address 4000_{HEX} and can be as long as 32k bytes. The board

Programs, board, PLD available

Because of space limitations, EDN cannot print the monitor or driver program listings. However, the programs, as well as the single-chip-µP board's PLD and a bare, documented circuit board are available from the author. Those interested should write or call Eric P Horton at Site 14, Cmp P-O, RR 2, Windsor Junction, Nova Scotia, Canada, B0N 2V0. Phone (902) 861-4755.—*Charles H Small*

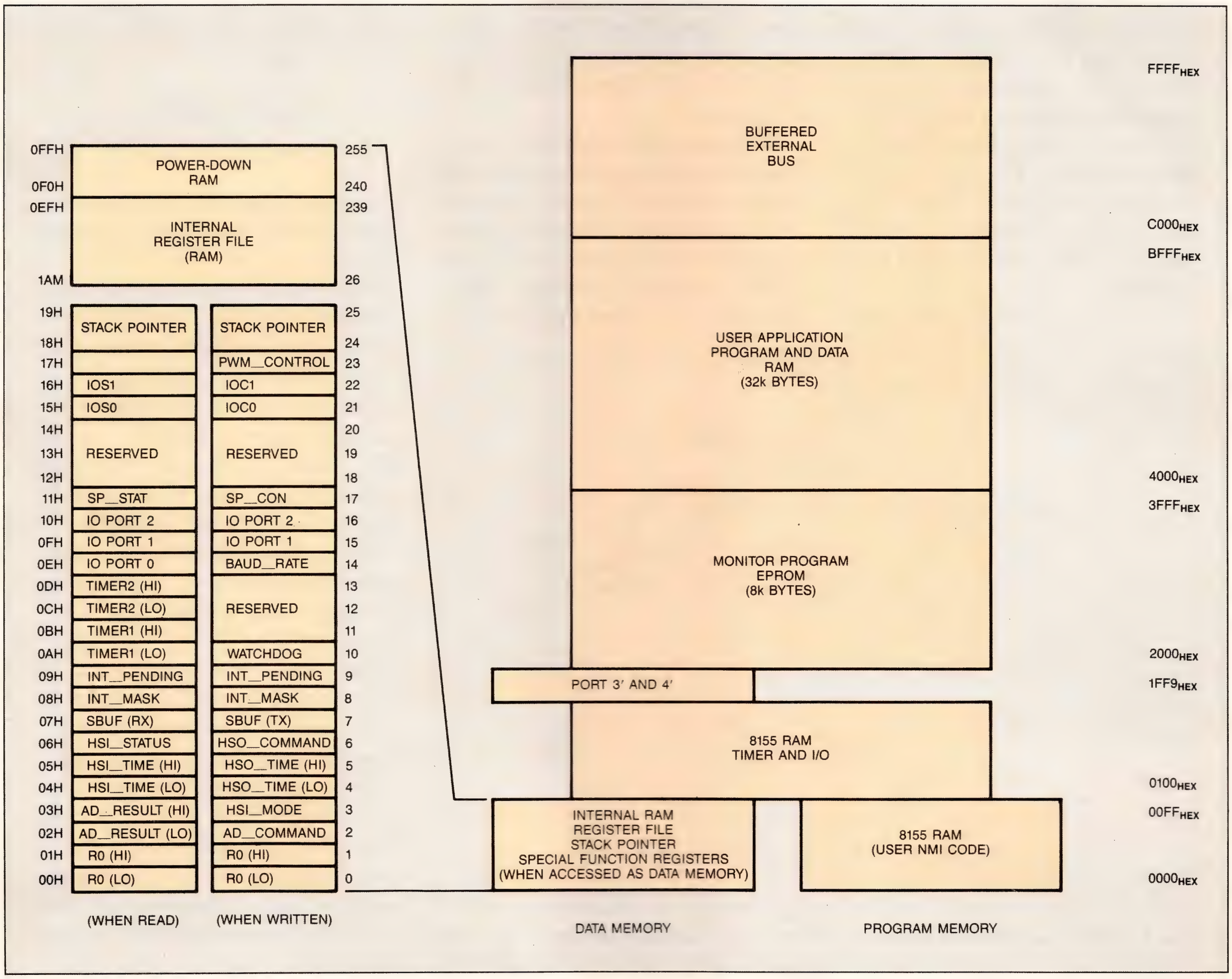

***Fig 2—The memory map for the board in Fig 1** indicates the divisions between the memory space occupied by the single-chip µP's internal registers and devices, the external devices, and the various memory devices.*

You can test single-chip-μP programs without the complex debugging facilities provided by expensive emulators if you write well-structured programs.

has a 28-pin socket that can hold various memory chips, including the 43256 RAM; an 8k-byte 6264; and certain versions of the 2764 EPROM, such as the TMS 2764 (pin 1 compatible). If you use a 6264 RAM, its address space begins at 6000_{HEX}.

A 16k-byte section of this system's memory is decoded and reserved for external-bus interfacing. This section begins at address $C000_{HEX}$. The control signals

Controlling a robot arm in C

An example of how you can take advantage of the function calls and libraries of C to speed single-chip-μP project development, consider the robot arm in **Fig A** controlled by an 8096 single-chip μP. The most complex software problems in this design are, first, calculating the angles between the various segments of the robot's arm necessary to position the robot's hand at a specified point in space, and, second, determining the arm's actual position in space as derived from sensors. C makes short work of these problems.

As is typical of an embedded-control application, the robot's main program is an infinite loop. The host system downloads the coordinates for the desired position of the robot arm in floating-point format via the single-chip μP's serial communication interface. These values specify the robot arm's location and the angle for the tool at the end of the robot's arm.

The embedded software then calculates the angles required for each joint of the robot's arm from the downloaded data using floating-point math. If the robot's operator's switch is enabled, then the software scales these calculated angles to match the range of the measurement system, converts them to integers, and passes them to the servo-control routine.

The software can pass these parameters in selected RAM locations, which you establish with a line of C code:

```
#define mailbox
( * ( unsigned int * ) ( OxXX )).
```

You could also pass the parameters by assigning them to global variables.

The digital-control servo algorithm is a conventional "proportional plus integral plus derivative" (PID) control algorithm implemented as a uniform time-series routine written in C. In the PID routine, if the error exceeds a given limit, then the control output assumes its maximum value; if the error is within the normal range, then the PID control algorithm applies. The software requires further limit and range checking to complete a fully workable control system.

An accurate measurement of the arm's position in space is a complex calculation because it requires combining the outputs of two types of sensors: optical encoders for coarse, 5- to 6-bit accuracy and precision resolvers. The two outputs result in an accuracy of 15 bits.

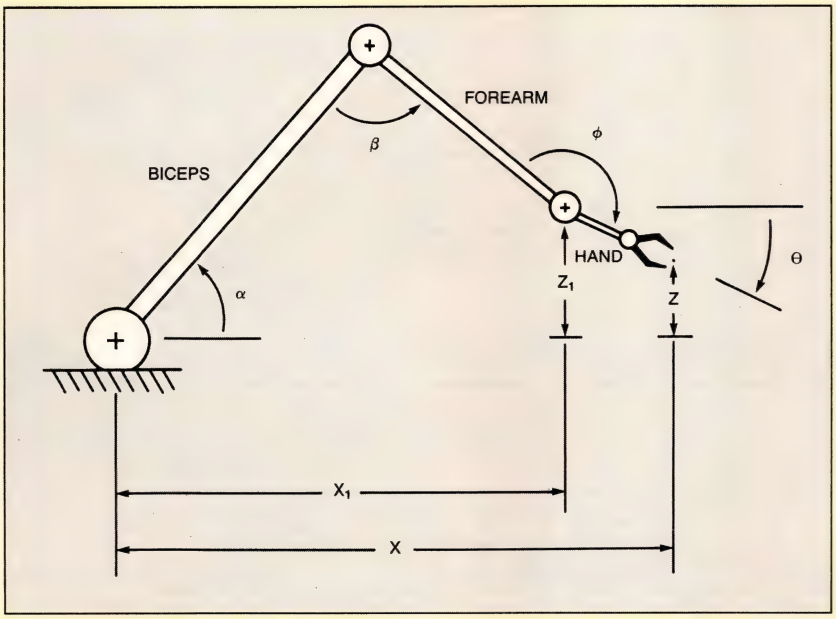

***Fig A—Control software for this robot arm** must first calculate the angles necessary to achieve a given robot-arm position. The software must then process the feedback signals from angle sensors at the arm's joints.*

Box continued on pg 136

that qualify memory accesses—$\overline{RD}$, $\overline{WR}$, and ALE—and most of the upper address lines are buffered. Also, the multiplexed lower address/data lines are gated through an octal transceiver to the outside world. Therefore, you can interface peripheral chips, including the 8000-series components, to the single-chip-μP board's buffered, external bus lines.

This board provides a relatively large I/O address

LISTING 1—PARTIAL LISTING OF ROBOT-ARM MAIN CONTROL LOOP

```
#include <stdio.h>
#include <io8096.h>
#include <math.h>

char swmask = 0x01 ;             /* mask for operator control switch */
char ans;

static int shoulder, elbow, wrist ;     /* for passing angles to PID */
float scaleup = 247.895 ;               /* scaling factor for angles */

float bicep, forearm, hand, k1, k2, x, z, x1, z1, c2, d, e ;
float alapha, beta, theta, phi ;

void main () {
  k1=bicep * bicep + forearm * forearm;
  k2 = 2 * bicep * forearm;
    while(1){
      scanf("%f %f %f",&x, &z, &theta);
      x1 = x;                                   /* calculate joint */
      z1 = z;                                 /* angles required by */
      c2= x1 * x1 + z1 * z1 ;               /* new input parameters */
      d = ( k1 - c2 ) / k2 ;                            /* from host */
      e = forearm * sqrt ((1 - d * d)/d ) ;
      alpha = asin (  e ) + atan ( z1 / x1 ) ;
      beta = acos( d );
      phi = alapha + beta + theta ;
          if ( IO_PORT1 && swmask ) {  /* operator enable switch on ? */

                shoulder = alpha * scaleup ;      /* convert floating */
                elbow = beta * scaleup ;         /* point to interger */
                wrist = phi * scaleup ;  /* for PID interrupt to use */

                   if ( shoulder == mshldr()      /* comparing each   */
                        && elbow == melbow()     /* calculated angle  */
                        && wrist == mwrist() )   /* to measured angle */

                           ans = 'C' ;                /* move complete   */
                    else
                           ans = 'M' ;                 /* arm in motion */
         }                                  /* end of operator switch test */
      else
           ans = 'D' ;               /* move disabled by the operator */

    sendf ( "%c\n",ans )                     /* serial transmit to host */

  }                                             /* end of while loop */

}                                                    /* end of main */
```

Controlling a robot arm in C *(Continued)*

The 8096 single-chip µP and C provide many of the resources necessary to attack these problems. These resources include floating-point arithmetic with trigonometric functions, serial communications, analog-to-digital conversion of analog inputs from joint-angle encoders, processing of digital inputs from the robot's operator and digital joint-angle encoders, parameter passing to interrupt routines written in C, and pulse-width-modulated outputs for the servo-motor drives. **Listings 1** and **2** show examples of C code for some of these functions.

The software handles the interface to the angle-measurement subsystem as a separate function. Because these calculations use only integer quantities, the 16-bit architecture of the 8096 often enables many lines of C code to compile directly into a single 8096 instruction. This routine executes rapidly because of the small number of actual single-chip-µP instructions required.

The angle-measurement system at the major joints of the robot's arm can achieve 15-bit resolution. This system combines digital and analog approaches using coarse rotation encoders and geared resolvers for fine measurements. Overlapping dual-precision potentiometers in a ratiometric configuration could substitute for the fine angle-measurement resolvers.

Processing the resolver's signals to measure 360° of rotation requires integer multiplication, division, and arcosine functions. In this application, the single-chip µP samples both of the resolver's output voltages at the peak of the reference-voltage cycle. The samples are taken virtually simultaneously because the single-chip µP takes them only 25 µsec apart. The software evaluates the signs of the resolver voltages and determines the effective quadrant the resolver is in and, therefore, the actual value of the lower eight bits of the measured joint angle.

At the end of the main loop, the software transmits a single character back to the host system. This character indicates if the arm is presently in motion or has completed the desired movement or if the operater has disabled control.

LISTING 2—PID-ALGORITHM SETPOINT CONTROL VALUES

```
/* A timer interrupt PID servo control routine, input data from mainline   */

extern int mshldr(), shoulder ;                    /* measurement and input data */
extern void pwm( int ) ;                   /* pulse width modulated motor drive */

static int past,integral ;
constant int maxerror = 165, maxout = 2000 ;
constant int kp = 13, ki = 21, kd = 16 ;          /* gain constants for PID */
int  error, out, derv,present ;

void shoulder_pid (void) {

 present = mshldr() ;
 error = present - shoulder ;               /* present shoulder angle error */
 if ( ( error ) > maxerror ) {
    integral = 0 ;                                      /* two stage control */
      if ( error > 0 )                      /* full output for large errors */
        out = maxout ;                           /* or PID for small errors */
      else
        out = - maxout ;
    }
 else {
    integral = integral + error ;
    derv = past - present ;
    out = kp * error +                        /* calculating the PID control */
          ki * integral +
          kd * derv ;
    }
 past = present ;                           /* shifting the samples in time */
 /*pwm (out) ;*/
}
main(){
}
```

Designers of single-chip-μP systems often reduce the number of external logic chips by using the upper address lines directly as control lines for peripherals.

space because designers of single-chip-μP systems often reduce the number of external logic chips by using the upper address lines directly as control lines for peripherals. For example, A_8 might function as a chip-select or a register-select line. This approach eliminates the need to latch the lower 8-bit address bus.

The hardware

The board uses relatively low-cost, industry-standard components for its EPROM, RAM, and peripherals. The memory components on the board are standard byte-wide devices used in a typical 8-bit, multiplexed address/data bus.

A single PLD performs address decoding, breakpoint detection, and other glue-logic functions, and contains all of the logic functions necessary to control emulation. The PLD makes this board simpler and less expensive than similar single-chip-μP boards for the 8051 and 8048 (**Refs 1** and **2**). **Fig 3** shows the PLD's equations.

Because this single-chip-μP board and monitor use two of the μP's I/O ports internally, the 8155's A and B I/O ports take the place of the μP's ports 3 and 4. Additionally, the monitor program uses the 8155's port C to control various system functions. For example, SW is the designation of one of the 8155's port C lines and is a software-controlled memory-map switch. When activated, SW deselects the monitor program, which resides in the single-chip-μP board's EPROM, and switches in user RAM to occupy the memory space formerly occupied by the monitor. You can use this SW function in the later stages of program verification to test your final target code without the system monitor being present.

The 8155 is the slowest component on the board because it has an access time of 330 nsec. The rest of the components are 180-nsec devices. An 80C196 operating at 12 MHz requires, therefore, two wait states when interfacing with the 8155. The READY line and the single-chip μP's internal chip-control register (CCR) provide this timing control by inserting only two wait states if READY is maintained as a low input by the chip-select line for the 8155. Thus, with the CCR properly initialized, the single-chip μP can accommodate a slow peripheral without resorting to a hardwired handshake.

The 5V-powered transmitter/receiver for the RS-232C interface helps to reduce the complexity of this single-chip-μP board. You will need the 244 buffer and 234 transceiver only if you use the external-bus option.

Unlike the emulators described in **Refs 1** and **2**, the hardware-breakpoint logic of this single-chip-μP board does not require a latch for the interrupt line because the 8096 internally latches the low-to-high transition on its EXINT pin. A resistor pulls up the data output of the 64k×1-bit breakpoint memory to maintain the memory in the inactive state if you do not select the hardware-breakpoint facility.

You can connect your target hardware to the single-chip μP's emulated pins via several 20-pin, 2-row head-

```
PAL16L8
ver 9.7

A13 A14 A15 RD SERIN SW EXTINTX BKWEN BKPTEN GND
INTSST 8155 DOUT RAM RW EXBUS EXTINTA EXTINT EPROM VCC

/EXTINTA = SW*/RAM*/INTSST
         + /DOUT*BKPTEN
         + /SERIN*INTSST
         + EXTINTX

/EXTINT = EXTINTA

/RW = /BKWEN*/RD

/EXBUS = A15*A14

/8155 = /A15*/A14*/A13

/EPROM = /A15*/A14*A13*/INTSST
       + /A15*/A14*A13*SW

/RAM = /A15*A14*/INTSST*SW
     + A15*/A14*A13
     + /A15*A14
     + /A15*/A14*A13*INTSST*/SW
```

Fig 3—These equations for the PAL16L8 PLD *define a logic specification that comprises all of the board's breakpoint, single-stepping, and address-decoding logic.*

Because of the 8096's register-to-register architecture, you'll usually be interested in only a specific section of the chip's register files.

ers. The pinouts of the header correspond to the pinouts of an 8096 packaged in a 68-pin PLCC. The headers also carry a few extra ground pins.

You access the board via the monitor's software UART. Through this serial connection, you can examine and modify any of the single-chip μP's internal and external features: RAM registers, special-function registers, I/O ports, and program and data RAM. You can also examine peripheral chips connected to the system via the system's external bus. You can download and upload program code in standard Intel hex format.

Table 1 lists the monitor's commands. Commands for debugging your application program include single stepping, breakpoint operation, auto stepping, auto breakpoint, and no-break execution at full system speed.

The breakpoint facilities include unique hardware breakpoints. The 64k × 1-bit 6287 breakpoint memory shadows the main memory. When you use the monitor command to set a hardware breakpoint at a given address, the board's hardware sets the corresponding bit in the breakpoint RAM low. The breakpoint RAM halts execution via the 16L8 PLD whenever the address bus selects a breakpoint-RAM location that holds a bit previously set low. You use these hardware breakpoints just as you would the more familiar software breakpoints. However, software breakpoints work via the usual method of inserting TRAP instructions into your application program's code.

The monitor's single-step function generates an interrupt when the single-chip μP fetches the next instruction from the user RAM following the last RETURN instruction in the monitor program. After the μP executes one instruction in your application program, it acknowledges the monitor interrupt and returns to the monitor program. The RESET switch forces the μP to return control to the monitor program if an application program disables the monitor's interrupt and then gets stuck in an endless loop.

If you need more complex breakpoint triggers than those the monitor provides, you'll have to modify your program to include temporary test code that initiates a break when a particular set of criteria are met. Testing a register and breaking when it contains a certain value is an example of this approach.

The board's onboard monitor program is simply a large EXTINT interrupt routine. The more flexible modes of addressing available on the 8096 as compared with the 8051—especially indexed addressing using the zero register (R0) and indirect addressing using the registers as 16-bit pointers—ease the monitor program's task. The monitor program includes a software UART that operates at 9600 baud when communicating with the board's host. A slightly modified version of the monitor program accommodates the 80C196 and its increased execution speed, increased interrupt capability, and added special-function registers.

The monitor program begins operation by temporarily storing the contents of a block of 10 of the 8096's internal registers in the 8155's RAM beginning at $01A_{HEX}$. This storage provides some workspace in the single-chip μP for the monitor's own routines. The re-

TABLE 1—MONITOR COMMANDS

COMMAND	POINTER	COMMAND DESCRIPTION
A0	WXYZ	AUTOMATIC ON BREAKPOINTS FROM POINTER ADDRESS
A1	WXYZ	AUTOMATIC INSTRUCTION AUTO-STEP FROM POINTER
B0	WXYZ	BREAKPOINT OUT OF MEMORY AT POINTER ADDRESS
B1	WXYZ	BREAKPOINT INSERT AT POINTER ADDRESS
C0	WXYZ	CODE MEMORY EXAMINE/MODIFY FROM POINTER ADDRESS
C1	WXYZ	CODE INPUT RECEIVE HEX FILE IGNORE POINTER
C2	WXYZ	CODE TO USER SEND HEX FILE BEGIN AT POINTER
D0	WXYZ	DATA OUTSIDE EXAMINE/MODIFY EXTERNAL DATA
D1	WXYZ	DATA INSIDE EXAMINE/MODIFY INTERNAL DATA
E0	WXYZ	EACH ON BREAKPOINT STOP AT NEXT BREAKPOINT
E1	WXYZ	EACH INSTRUCTION SINGLE STEP FROM POINTER
F0	WXYZ	FULL OPERATION FULL SPEED FROM POINTER ADDRESS
FF	WXYZ	FIX FORMAT SELECT REGISTERS FOR RUN REPORT

turn address for the application program also gets stored in the 8155.

The monitor then transmits a register report **(Fig 4)** to the user. This report lists the present values of a selected block of the single-chip μP's internal registers and the values of some or all of the special-function registers. The report for the special-function registers displays each title above the data value to eliminate any need to remember the actual addresses of each of these registers. Depending on the command you have previously given the monitor, the monitor may return to executing your application program until it encounters the next breakpoint, or it may simply wait for you to key in the next command.

There is a time delay between the monitor's displaying of a screen of information and its resuming execution. This delay proves useful when you're debugging a system and using automatic-mode monitor commands because it gives you time to digest the screen's information before execution resumes.

Because of the 8096's register-to-register architecture, you'll normally be interested in only a specific section of the μP's register files while testing your application program. You can select a section of the 8096's register files to be displayed in byte-wide or 16-bit-word formats at breakpoints as part of the register report. This section can be as large as 64 bytes.

Similarly, you can increase the register report's size to display a full screen of data, including the selected block of data registers and all of the readable special-function registers. Conversely, you can limit the size of the complete register report to as little as a single line showing just the program counter, program-status word, and next op code.

Interrupting interrupts

The interrupt structure of the 8096 lets each interrupt routine selectively enable other interrupts while in progress. Earlier Intel single-chip μPs don't acknowledge interrupts that occur while an interrupt routine is running. But if your interrupt routines can enable the monitor's interrupt (EXTINT) during their execution, you can use the monitor to debug your interrupt routines.

The normal starting point for developing an application program with this system is creating an assembly-language source file on a PC. Any of several crossassemblers **(Ref 3)** available for PCs will produce a file in the standard Intel hex format. You can then use virtually any communication program to download the

```
    PC       OP   PSW    STACK PTR
   0220      C6   1280   OODO

  REG 30     31     32     33     34     35     36     37
      B1     AC     C1     04     2C     59     70     1E

      PO     P1     P2     P3'    P4'
      00     FF     F9     03     00

    IOSO  IOS1
     00    20

  INT_PEND  INT_MASK
     7F      80

  SP_STAT SBUF
      4     00

  AD_STAT CHNL RESLT
      0    0    3FC

    TMR1   TMR2 HSI_TIME STAT
    3D95   0000  0000     00
```

***Fig 4—At a breakpoint, the board's monitor** sends this full-length report, which displays an 8-byte (or larger) block of the single-chip μP's register file and its readable special-function registers, including the on-chip I/O ports and the static replacement ports in the 8155.*

hex code to this single-chip-μP board for testing and debugging.

At this point, you can use the board alone to simulate the hardware during your initial software-design stages. Or you can connect your specfic target-system hardware to the emulated single-chip-μP pins. For example, you can use the serial communication routines contained in the monitor program EPROM to simulate a serial interface that you plan to add later in your project's development. For the simplest form of machine-level debugging, use the list file produced by the crossassembler as a reference to indentify the addresses and op codes of each instruction and to indicate the memory locations of variables or pointers used in your application program.

In addition to this simple stand-alone mode, an assembly-language-level debugging facility is available for this single-chip-μP board (see **box,** "Programs, pc board, and PLD available"). A simple driver program running on an IBM PC handles all the serial interfacing to the board. This driver program transmits your commands and displays the selected data on the PC's screen.

The driver program acquires the address of each line of code from the list file of your application program. At each program break, the PC correlates the value of the program counter received from the single-chip-μP board with the corresponding address in the assembly code. The PC then displays the actual line of assembly code associated with the present value of the program counter on the middle of the PC screen along with the preceeding and following 10 lines of code. You can thus trace the execution of your application program line by line.

This driver program running on the PC can also display and update, at each program break, data associated with specific labeled variables, registers, special-function registers, memory locations, and I/O ports.

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SG1526B	SG3526B
SG1527A	SG3527A
SG1529	SG3529
Current Mode	
SG1825	SG3825
SG1842	SG3842
SG1843	SG3843
SG1844	SG3844
SG1845	SG3845
SG1846	SG3846
SG1847	SG3847
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CIRCLE NO 87

The interrupt structure of the 8096 lets each interrupt routine selectively enable other interrupts while in progress.

The driver program acquires the addresses of these items from the crossassembler's list file. This IBM PC driver also gives you access to all of the single-chip-μP board's modes of execution, including single stepping, breakpoints, and full-speed operation.

Fig 5 shows that debugging at the assembly level is easier on the eyes than machine-code level's hexidecimal codes. With assembly-level debugging, you're involved with debugging algorithms and program flow, not endlessly deciphering program code and register information expressed in hexidecimal notation. Assembly-level debugging thus significantly reduces the time required to test and debug application code. You can use this driver program even when the I/O pins of the single-chip-μP board are connected to your target system, and you can test your application code at full speed. This combination provides many of the source-level debugging facilities of a single-chip-μP software simulator with the advantage of having some or all of the prototype application hardware actually connected to the I/O pins.

The IBM PC driver program can also handle programs written in C. The C programming language has displaced older, less useful languages, such as Fortran and Pascal, as one of the more popular choices, along with Forth, for programming single-chip μPs (**Refs 4** and **5**). Several C cross compilers are available that run on IBM PCs and produce hex code for the 8096 (**Ref 6**). This "medium-level" language can produce fast and efficient code because of its close interaction with the instruction set of a target μP. This interaction is closer than that of other, so-called, high-level languages, which deliberately insulate the software engineer from the hardware.

Also, C gives you some measure of portability—an important consideration given the significant time required to master the instruction set of a new μP. Portable software becomes the nucleus of a reusable design kernel—to a far greater extent than any common hardware might—when you write it in C. C compilers also provide you with easy access to integer and floating-point math library routines and complex logical expressions. The presence of these facilities and functions is one of the many reason for programmers to move up to C from assembly language.

C compilers produce a list file that combines each line of C code with the associated lines of assembly code. From this list file, the driver program can determine the actual instruction addresses that correspond to each line of C code. The driver program running on a PC receives the program counter's value at each program break from the single-chip-μP board. The PC then correlates this value with the line of C code that is associated with that particular address. **Fig 6** shows how the driver displays this line of C code together with the previous and following lines. You can thus easily trace and debug your C program's flow and execution.

A map file produced by the linker program indicates where variables, which you declare in your C program,

```
      SP      00D0  hex              A      0103  hex            P1      FF  hex
      R2        00  hex              A       259  dec            AL      03  hex
      R1        01  hex

  -- Auto-step, Step, Run, Breakpoint, Terminal, Variable, Fileview, Dos, Exit ---

           0208                      LDB R2,#0FFH
           020B                      STB R2, [R1]
           020E                      LD R1,# P3A
           0212                      CLR A
           0214 LOOP1:               ADD A,#0103H
           0218                      STB AL,[R1]
           021B                      LCALL BIT1DLY
     PC >> 021E                      INC A
           0220                      STB AL,[R1]
           0223                      LCALL BIT1DLY
           0226                      JBC P1,5,LOOP1
           0229 LOOP2:               SUB A,#0105H
           022D                      STB AL,[R1]
           0230                      LCALL BIT2DLY
           0233                      DEC A
```

Fig 5—This display is a typical screen report *from an assembly-language-level debugging session. You can use your IBM PC's screen-print feature to take a snapshot of these screens at any time.*

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C gives you some measure of portability—an important consideration given the significant time required to master the instruction set of a new μP.

```
   num        247  dec                 inc        10  dec              port0       FE  hex
 port1         FF  hex

  -- Auto-step, Step, Run, Breakpoint, Terminal, Variable, Fileview, Dos, Exit ---

          else{
              return(FALSE);
          }
     }


     void inc_var_num()           /* increment the global variable num */
     {
          num++;
 >        if(num == 255){
               num=0;
          }
     }

     main()
     {

          while(1){
               if(get_bit_p01()){
```

Fig 6—Similar to Fig 5, this display is an example *of a typical screen report from a debugging session for a C program. A driver program running on your IBM PC can correlate the current program counter's value with the corresponding line of code in your C program.*

are actually located in the board's memory. The driver program thus can similarly correlate the variable's name with its physical location.

Static variables are easier to debug than automatic variables because static variables have a specific assigned address in the data-memory space but automatic variables have addresses assigned on a temporary basis. The driver program uses this addresss information to obtain the present value of each selected variable and display it in one of several available formats, which include hexidecimal, decimal, ASCII, and floating point. You can execute and test your C applications programs in all available modes, including the use of breakpoints set on specific lines of code. As with machine-level and assembly-level debugging, you must modify your C program if you want to set up complex breakpoints. EDN

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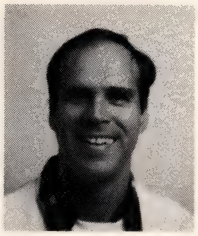
Author's biography



Eric P Horton is an engineer for the Nova Scotia Power Corp. He also owns a consulting firm called Dedicated Computer Systems, which does contract single-chip-μP system design and development. He holds a BSc in math from Acadia University and a BEE and MEE from the Technical University of Nova Scotia. In his spare time, he enjoys building a new energy-efficient home, being a leader in Wolf Cubs, skiing, and playing volleyball.

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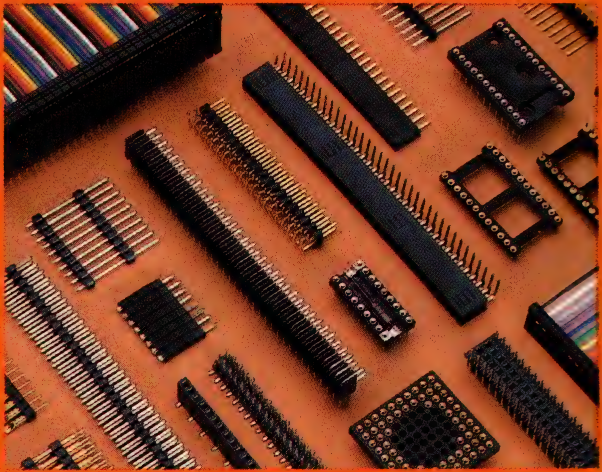

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CIRCLE NO 91

Dynamic modes refine synchro-to-digital converter testing

More accurate testing of high-performance motion-control systems that use synchros or resolvers as position transducers and S/D converters is now possible. A look at various tests for an S/D converter shows how contemporary synchro simulators make testing easier as well.

Franklin W Smith, *Natel Engineering Co Inc*

High-performance motion-control systems often use synchros or resolvers as position transducers, and synchro/resolver-to-digital (S/D) converters to interface with digital control systems. But the testing of S/D converters has long been hampered by limitations in accuracy. A new generation of synchro simulators, however, can now achieve resolution and accuracy values that make dynamic as well as static tests possible. A look at the testing of the S/D converters shows both how the S/D converters work within the motion-control systems and how the synchro simulators aid in testing them.

A simple, working definition of a motion-control system is one in which the mechanical position, motion, and/or velocity of a device is under the closed-loop control of a digital computer. **Fig 1** is a simplified functional block diagram of a motion-control system. The position input data might be the digital output from a computer or magnetic tape, for example. An S/D converter converts the position of the device, represented by synchro analog data θ, to a digital representation and sends this signal to the computer.

The computer then compares the actual position to the desired-position data and determines what is required to move the device to the desired position. It generates a digital correction signal which, when converted to dc by a D/A converter, drives a dc torque motor to reposition the device.

An important feature of this system is that the dynamic compensation of this closed loop is completely under computer control. Thus you can alter the stability of the system and its response characteristics by modifying algorithms residing in computer firmware or software. In some sophisticated systems, modification of the response characteristics is adaptive.

An example of a very sophisticated adaptive control system is the Grumman X-29 forward-swept wing aircraft. The design is so inherently unstable that manual controls alone are inadequate to fly the plane. The computerized digital flight-control system makes 40 corrections per second to the positions of the wing and canard surfaces to compensate for this inherent instability, providing constantly optimum aerodynamics. The result is an extremely agile, high-performance combat aircraft.

In a typical test of an avionics system, you usually test only a portion of the motion-control system at a particular time. Your task might entail testing the avi-

In some sophisticated systems, modification of the response characteristics is adaptive.

onics box, which may consist of the S/D converter, the computer, and the D/A converter **(Fig 2).** The controller sends simulated position commands to the synchro simulator. A digital voltmeter (DVM), or a waveform digitizer, digitizes the DAC's dc signal output and sends it to the controller. In some cases, a printer records the test results.

Another approach to system test and evaluation is to exercise each of the individual functional blocks (like the S/D converter and the DAC) separately and then, using the test results, predict the integrated system performance by implementing network theory. To show how this approach works, consider analyzing the tests for the S/D converter block (see **box,** "How a synchro-to-digital converter works").

Tests can be static or dynamic

Any thorough testing of motion-control systems should involve both static and dynamic aspects. Static tests are all those that you perform between motions, when the system is motionless; you test dynamically, on the other hand, while the system is in motion. Static tests include those for position accuracy, system resolution, repeatability of position accuracy, and environmental effects (such as temperature, humidity, shock, and vibration) upon these parameters.

The latest generation of synchro simulators provides angular data in resolutions from 0.001° to 0.0001° with an accuracy range from 0.006° to 0.001°. In addition, these devices can test dynamic modes, including continuous rotation, both clockwise and counterclockwise; and sine-, triangular-, and square-wave modulation of motion. Dynamic tests cover position accuracy while the synchro is in motion at a constant velocity (tracking); position accuracy while accelerating; determination of maximum tracking rate and maximum slew rate; evaluation of settling and damping characteristics; and system bandwidth and stability testing.

Static position tests are the simplest

Position or angular accuracy testing is the simplest and most frequently performed static test. For the S/D converter, the sequence of test steps resides in the controller; it furnishes a series of predetermined test angles to the synchro simulator **(Fig 3).** The logic analyzer allows the converter to settle after each test value and then sends the converter's digital output to the controller. The controller calculates the difference between the S/D converter's output code, and the expected code for each angular test. The difference is the measurement error, which the controller passes to the printer to provide a data-sheet listing of test number, test angle, error, and pass/fail information. (Depending upon test complexity, you may want to stop the test at an abnormal reading to sound an alarm and to prompt the operator for a choice of options such as

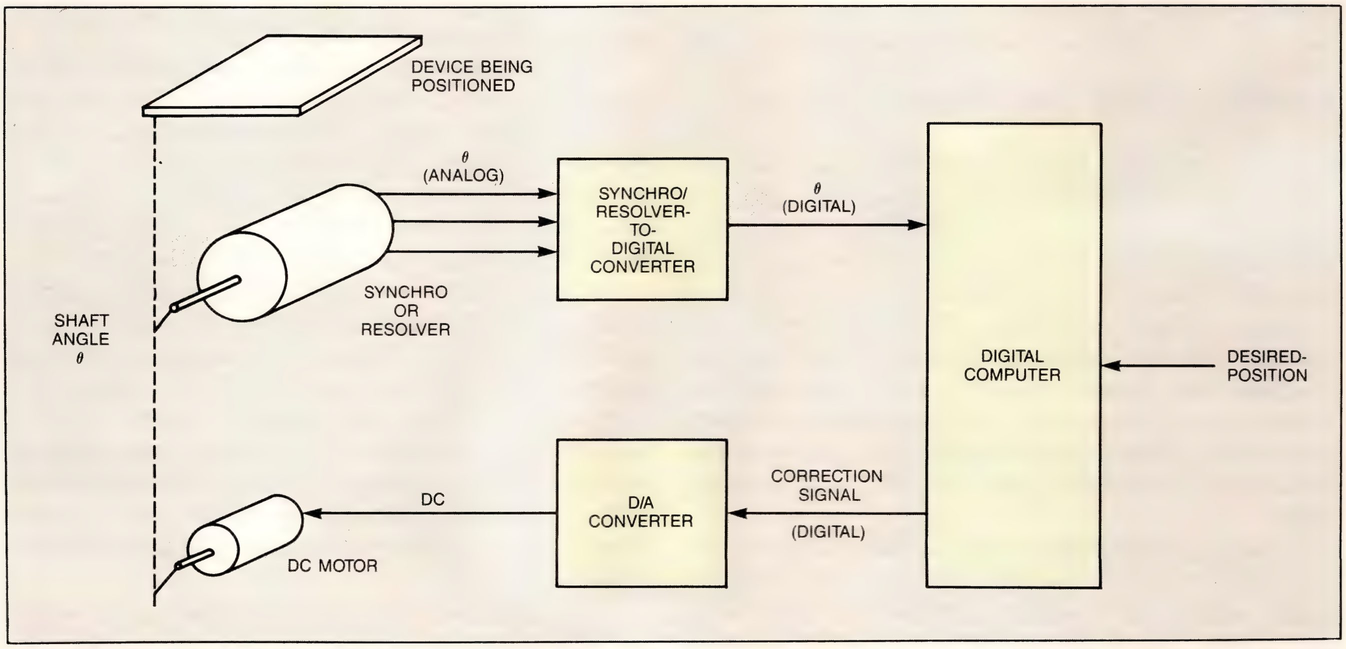

Fig 1—A digital computer positions a device *by comparing the location of the device to the desired position that the digital input described.*

"Abort Test" or "Continue.")

Because some of the S/D converter's parameters are inherently stable, you need to vary these parameters only when you perform angular accuracy tests. Such parameters include simulated synchro phase shift; signal and reference-voltage high/low lines; and reference-frequency high/low limits.

The time involved in positioning the servo manually has made angular accuracy testing burdensome in the past. However, under the automated control of the newer synchro simulators, you can run the tests quickly and virtually unattended.

You can calculate the theoretical resolution of a S/D converter by starting with the number of output bits—14 bits = 0.022° resolution, 16 bits = 0.0055° resolution, or simply resolution = $360°/2^n$, where n = number of bits. You can also measure the resolution as follows: Starting at some predetermined angle, for example 1.0000°, increment the simulator in 0.0001° steps until the S/D converter's LSB output changes state. At that time, note the simulator's angle. Then continue to increment the simulator in 0.0001° steps until the converter's LSB output changes state again. Subtract the first simulator angle from the second to obtain the actual resolution. Finally, you should repeat the test, decrementing the simulator.

Contemporary tracking S/D converters use hysteresis to avoid jitter or oscillations between adjacent bit steps. You can measure the hysteresis by first performing the resolution test outlined above. Then increment the simulator's input, but when you note the second bit change, start to decrement the simulator's input, so that you're approaching the first-bit change point. When you reach the first-bit change point (as indicated by the converter output), note the simulator angle again. Next, subtract this angle from the previous angle to determine the combined resolution-plus-hysteresis value, which is always greater than the angle of one LSB. Now, subtract the resolution you measured earlier from that combined value to calculate the hysteresis angle.

Repeatability doesn't mean accuracy

How consistent the S/D converter is, from measurement to measurement, defines its repeatability, which has no connection to accuracy. A converter can have high repeatability but be completely inaccurate. Repeatability errors in S/D converters can result from the converter resolution, hysteresis, short- and long-term drift, and major bit-transition error effects. You can test short-term repeatability by running the same test several times in both ascending and descending directions. By varying data-point step increments, or by approaching a particular data point from both directions, you may also reveal repeatability errors.

Accelerated life-testing techniques help you to assess

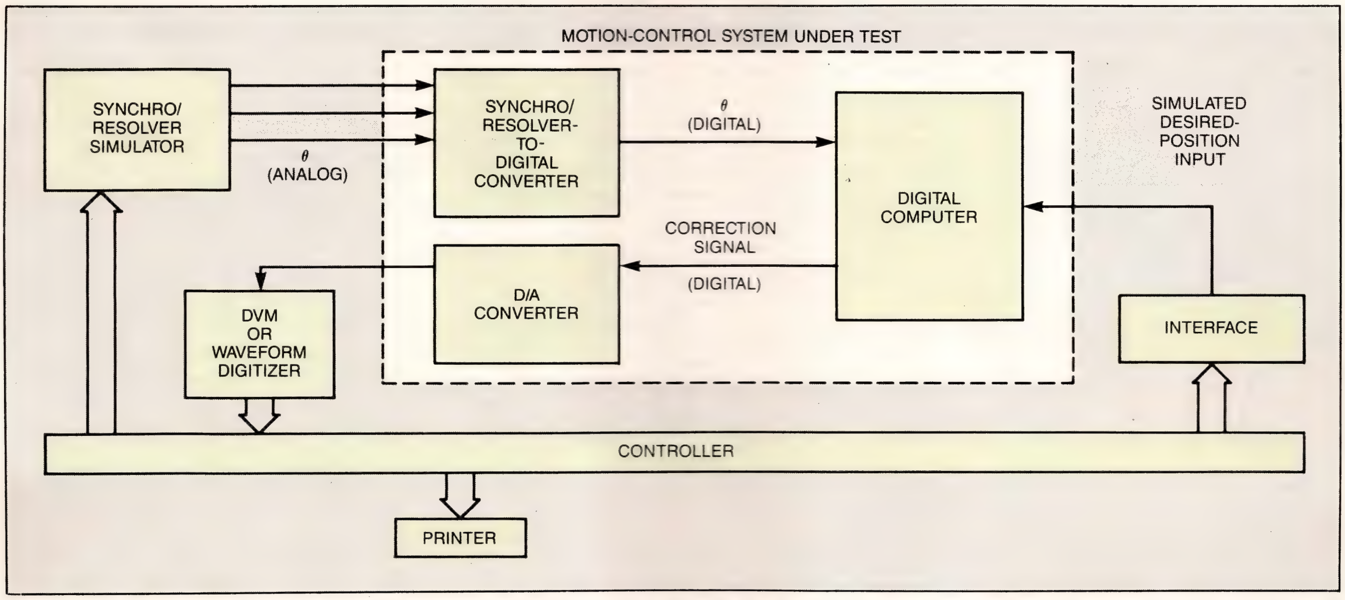

Fig 2—Testing a motion-control system *typically requires testing portions of the system in a particular test. The S/R simulator and the digital interface circuitry, which the controller simulates, drive the motion-control system. The DVM or waveform digitizer evaluates the output.*

Frequently, a motion-control system is partitioned into subsytems, which you can then test individually.

a device far beyond normal daily wear and tear. Reliability analysis suggests you can perform long-term repeatability testing by running accuracy tests over a period of time—six months, for example—using accelerated life-testing techniques, such as hot- and cold-temperature cycling and power cycling, which stress the converter. This technique allows you to reduce the waiting time between tests.

Dynamic tests measure position accuracy

Because the velocity constant of a type II tracking converter is, in theory, infinite, the instantaneous angular error between the input synchro signals and the output digital angle isn't degraded when the synchro is rotating. Simply put, the error will be the same as the static error at that angle. This condition is valid for constant rotation speeds to the converter's maximum tracking rate (which is dependent upon both frequency and resolution).

By dynamically comparing the digital angle output of the simulator with the digital output of the converter, you can verify the position accuracy and the infinite velocity constant of a type II converter. You can implement this data comparison most easily with a general-purpose logic analyzer, which lets you compare the digital angle output of the simulator with the converter output **(Fig 3)**.

The S/D converter tracking rate is a measure of how fast a rotational speed can be converted accurately (or tracked) by the converter. In general, two parameters influence the ability of a synchro system that has a type II S/D converter to track quickly and accurately: the reference signal's frequency and the tracking resolution (measured in bits). The maximum tracking rate is directly proportional to the reference frequency and inversely proportional to the tracking resolution.

Most contemporary converters provide a BIT signal that goes to a logic one whenever the input rotation is faster than the converter can track, a situation that usually causes large errors). To test for tracking at the converter's rated specification, program the simulator for that tracking rate (such as 7200°/sec) and for clockwise rotation. Monitor the BIT signal output; logic zero indicates that the converter is tracking. Repeat the test for counterclockwise rotation.

To test for the maximum tracking rate, repeat the above test but gradually increase the tracking rate until the BIT signal changes to a logic one. Find the highest rate attainable while the BIT signal remains at logic zero. Repeat the test for the opposite direction of rotation. Many converters exhibit different maximum tracking rates in clockwise and counterclockwise directions, because of the asymmetry of the VCO (voltage-controlled oscillator). A manufacturer's guardbanding causes the actual maximum tracking rate to be higher than the tracking rate it specified; the actual rate may vary from converter to converter.

A converter's response to step changes in the input angle is specified as the large- and small-step settling times, t_L and t_S, respectively. A large-step specifica-

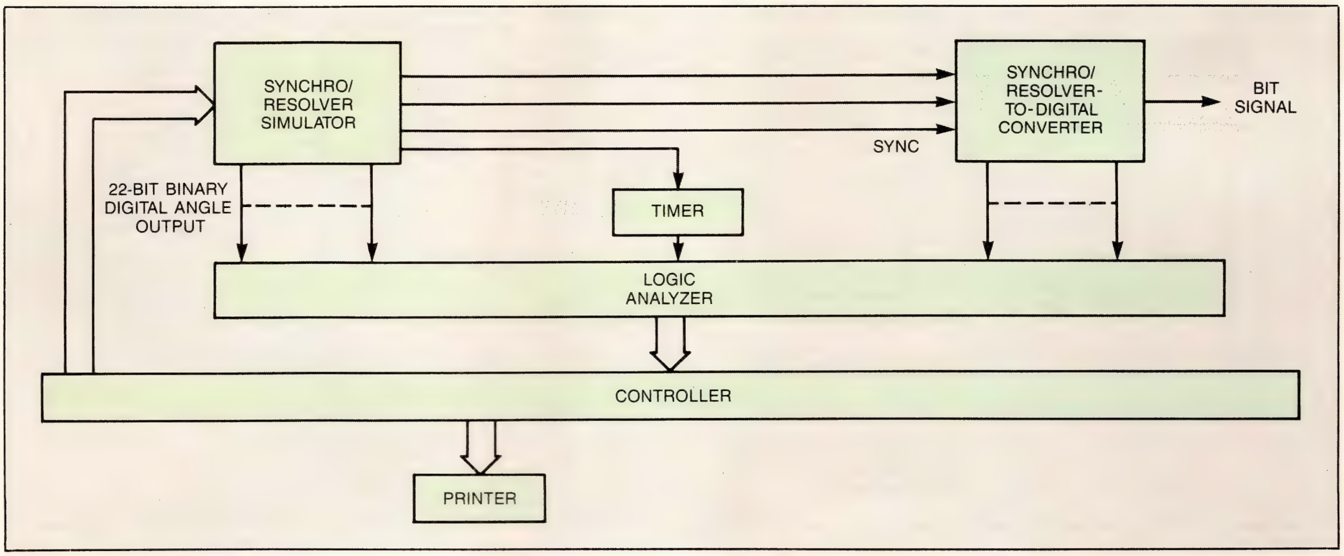

Fig 3—You can also test a motion-control system *by partitioning the system into its functional blocks and testing them individually. You can then use network theory to predict system performance and integrity.*

How a synchro-to-digital converter works

You can differentiate the type II tracking converter from its predecessor, the type I converter, by its velocity constant. Type I tracking converters feature one stage of integration and a finite velocity constant. In addition, type I tracking converters have a tracking error at a fixed velocity that is proportional to the input data rate. In contrast, a type II tracking converter has, theoretically, an infinite velocity constant and no lag error at constant velocity. Because of the limitation of the velocity constant and the tracking error inherent in type I converters under constant velocity, type II is the preferred design.

Fig A is a simplified functional-block diagram of a type II tracking synchro/resolver-to-digital (S/D) converter. The type II converter does produce a lag error under conditions of acceleration, and you can calculate this error by using the acceleration constant, which the vendor specifies for his particular converter.

The heart of the converter is a solid-state control transformer (SSCT). This device receives the SINθ and COSθ ac analog signals from the analog input circuits, and a digital word representing the converter angle ϕ. Most commonly used converters generate output in the range of 10 bits (0.352°) to 16 bits (0.0055°) resolution. The converter angle, ϕ, is a product of the binary up-down counter and serves as the input to the SSCT as well as the digital output of the converter. The output of the SSCT is an analog error signal with a magnitude and polarity (ie, a phase of either 0° or 180°) that are both proportional to $SIN(\theta-\phi)$. When the digital input word ϕ is equal to the synchro angle θ, the output of the SSCT represents $SIN(\theta-\phi)=SIN(0)=0$.

A phase-sensitive demodulator, driven by the conditioned ac reference, converts the analog error signal from the SSCT to a dc error signal. An analog integrator processes that signal; the integrator's output value is directly proportional to the velocity of the converter. The analog velocity signal drives a voltage-controlled oscillator that produces a clock train and an up/down control signal. Those signals in turn drive a binary up/down counter whose total word value represents the converter angle ϕ. The converter angle is then sent both to the SSCT and to the digital output. The logic sense of the error signal (and subsequently the VCO output) drives the up/down counter in the direction that causes the converter angle ϕ to equal the input angle θ.

In contemporary hybrid S/D converters, additional features are added to the basic design to improve the overall converter performance. A reference synthesizer eliminates errors caused by phase shifts between the synchro input θ and the reference input. An automatic gain control prevents errors resulting from line-to-line voltage fluctuations. And a built-in test detector provides an indication of an error condition in the motion control system.

The converters can also include octal 3-state buffered digital outputs that allow the use of 8-bit or 16-bit data buses, synchro/resolver programming, 14/16-bit resolution control, and single +5V dc operation, which eliminates the ground loop problems of earlier converters.

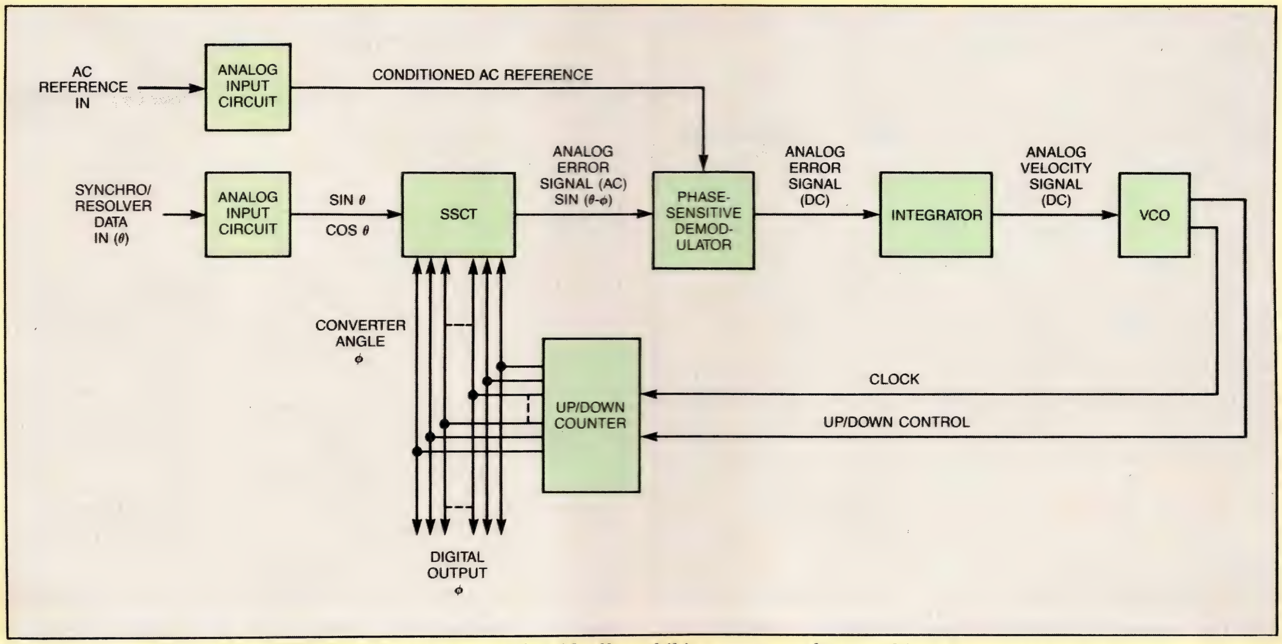

Fig A—A type II tracking S/D converter *is a servo that ideally exhibits no error when tracking at constant velocity.*

Designers add hysteresis to circuits in order to overcome the jitter and oscillation between bit steps that is a concern in S/D converters.

tion is usually 179°; a small one is 1.4°. The typical converter response to a large-step input is shown in **Fig 4**.

The large-step transient response depends primarily on the maximum velocity (ω max) and the maximum acceleration (α max) that the converter can achieve. You can subdivide the synchronizing time (t_{SYNC}) for large steps into three segments: acceleration time (t_{ACC}), which is the time from application of the step input to the time at which the converter reaches its maximum velocity; slew time (t_{SLEW}), which is the time from maximum velocity to the time at which the output angle is first equal to the input angle; and overshoot time (t_{OS}), which is the time interval from when the converter output angle first equals the input angle (and applies constant acceleration in the opposite direction) to when the output angle again reaches the input angle. At the end of the overshoot time, the small-step response becomes dominant, and the converter settles down to the final value according to its small-step transient-response function.

You can use the simulator to test large- and small-step settling time as follows: Set the simulator for square-wave modulation of angle (179° amplitude for large step or 1.4° for small step); the modulation period should be approximately four times the settling-time specification. Use the simulator's SYNC output to trigger the timer and to provide an output latch signal after a time-out equal to the settling-time specification of the converter. Use the latch signal to strobe the converter data into the logic analyzer. If the converter is working properly, the data that is latched equals the step angle (179° or 1.4°) to within the converter's specified accuracy.

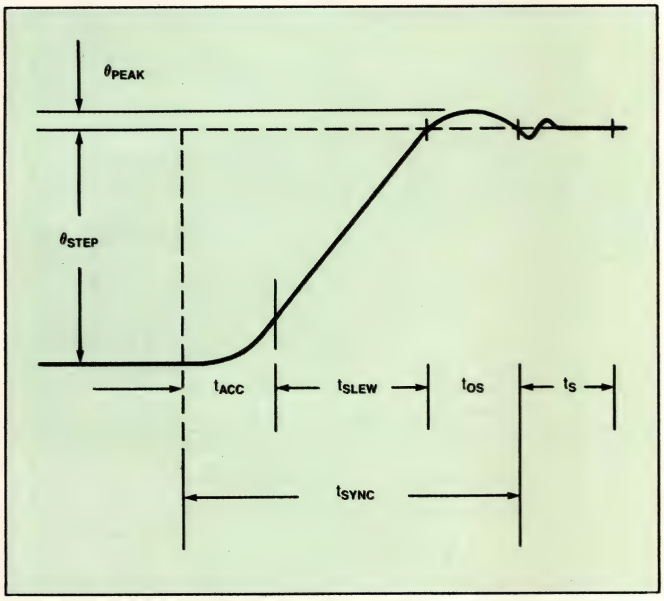

***Fig 4—The components of settling time are the acceleration time,** t_{ACC}; the slew time, t_{SLEW}; the overshoot time, t_{OS}; and the small-step settling time, t_S.*

Position accuracy vs acceleration

The acceleration performance of an S/D converter—in particular its acceleration constant and maximum acceleration—indicates how well the device adjusts to changes in the position or velocity of the input angle. A converter's acceleration constant, which you can obtain from the manufacturer, is a function of the converter's resolution, signal frequency, and design implementation. You can calculate lag error during acceleration by dividing the acceleration by the acceleration constant.

You can also use the acceleration constant to compute the converter's acceleration lag error to the maximum acceleration specification of the converter. The maximum acceleration is a function of the dynamic range of the converter's error circuits.

The best way to measure converter acceleration effects is to use sine-wave dynamic angle modulation. **Fig**

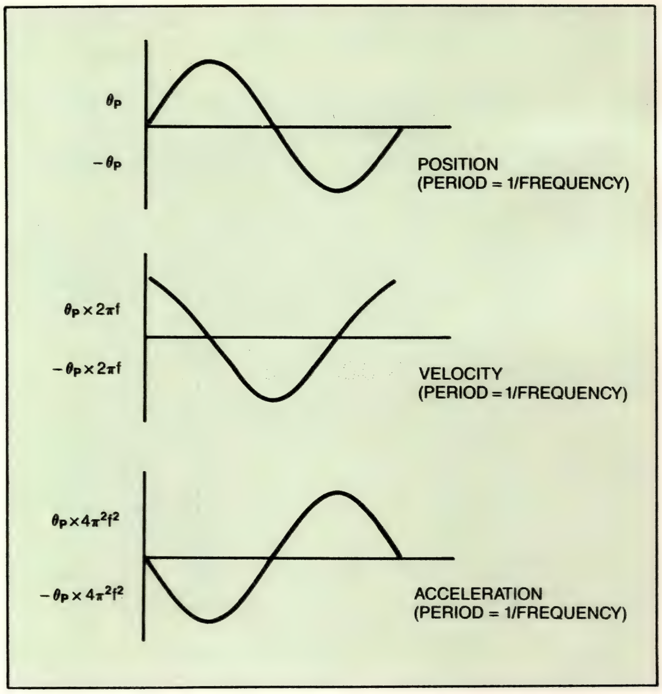

***Fig 5—Use sine-wave dynamic angle modulation** to demonstrate the relationship among position, velocity, and acceleration, as a function of the S/D converter acceleration.*

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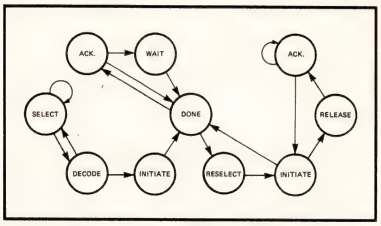

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The acceleration constant and the maximum acceleration of a converter determine how well a converter performs when the position or velocity of the input angle shifts.

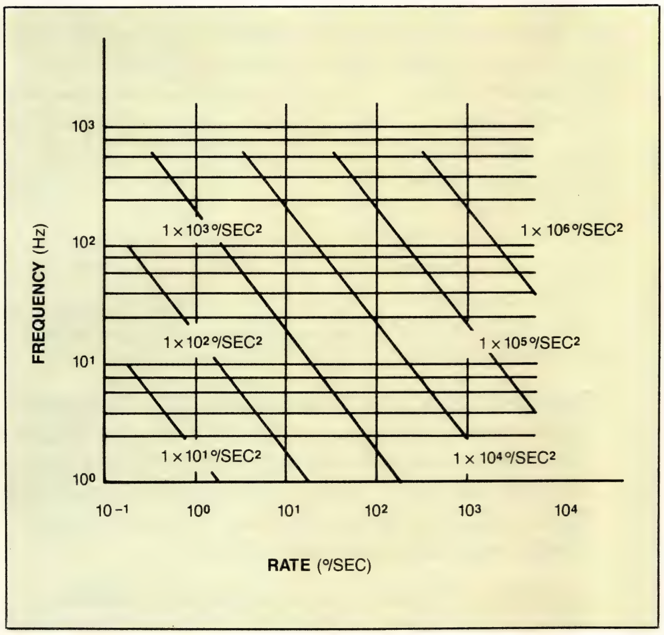


Fig 6—To produce a given acceleration, *you can trade off between the modulation rate and the frequency.*

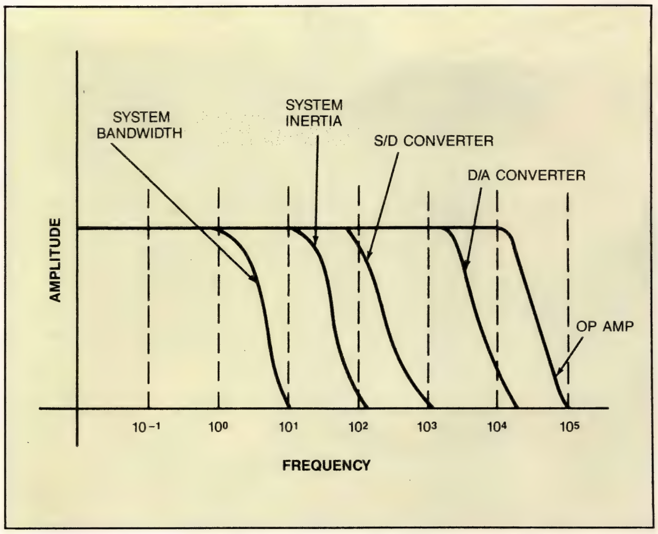


Fig 7—The bandwidth of a typical motion-control system *is less than the bandwidth of each of its components.*

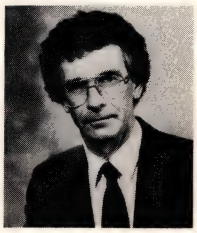
5 demonstrates the relationship between the angular position, velocity, and acceleration for a sine-wave angle modulation. Note that the points of peak acceleration and deceleration are at the positive and negative peak angles of the modulation envelope. At these points, you can monitor the converter's acceleration performance by triggering a logic analyzer off a square-wave reference signal from the simulator. You can calculate the converter's acceleration performance.

Fig 6 demonstrates the tradeoff between the modulation rate and the frequency required to produce a given acceleration. This graph represents 360° peak-to-peak modulation.

Examine system bandwidth

Fig 7 illustrates the relative bandwidths of typical motion-control system components compared to the combined system bandwidth. The modern synchro simulator is an excellent stimulus device for evaluating system response characteristics. By using sine-wave modulation and taking note of 3-dB attenuation points and unity-gain crossovers, you may examine both small-and large-signal bandwidths. You can program the controller to sweep the modulation frequency while you evaluate the response for peaking and roll-off. You should, however, exercise care to avoid exceeding the maximum tracking rate at high modulation frequencies. EDN

Author's biography



Franklin W Smith is a product marketing manager with Natel Engineering Co Inc (Simi Valley, CA). Prior to that, he spent 22 years on the East Coast with North Atlantic Industries. Frank earned an associate's degree from the State University of NY, and a bachelor of science degree from Adelphi University. Frank holds three patents and enjoys sailing, fishing, orchidology, and photography.

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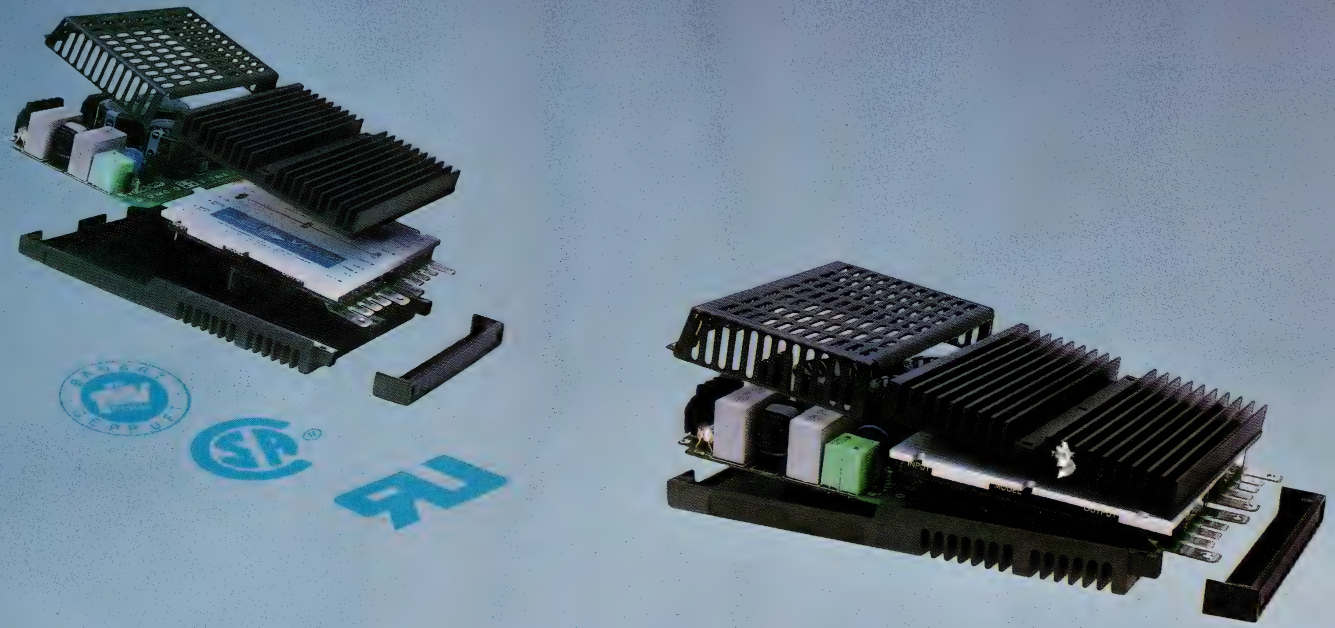

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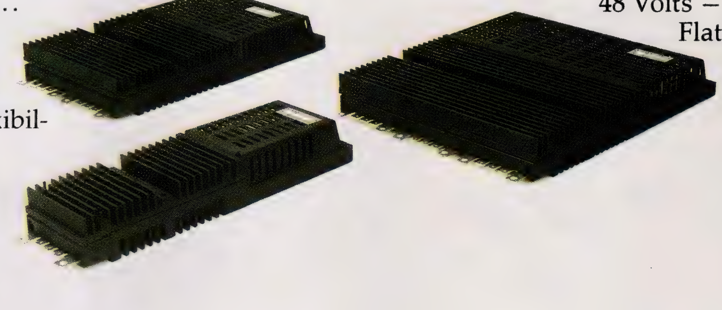

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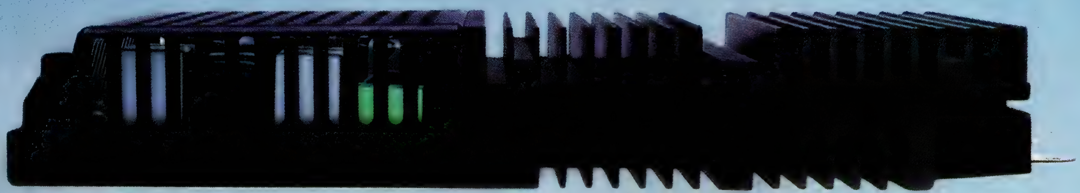

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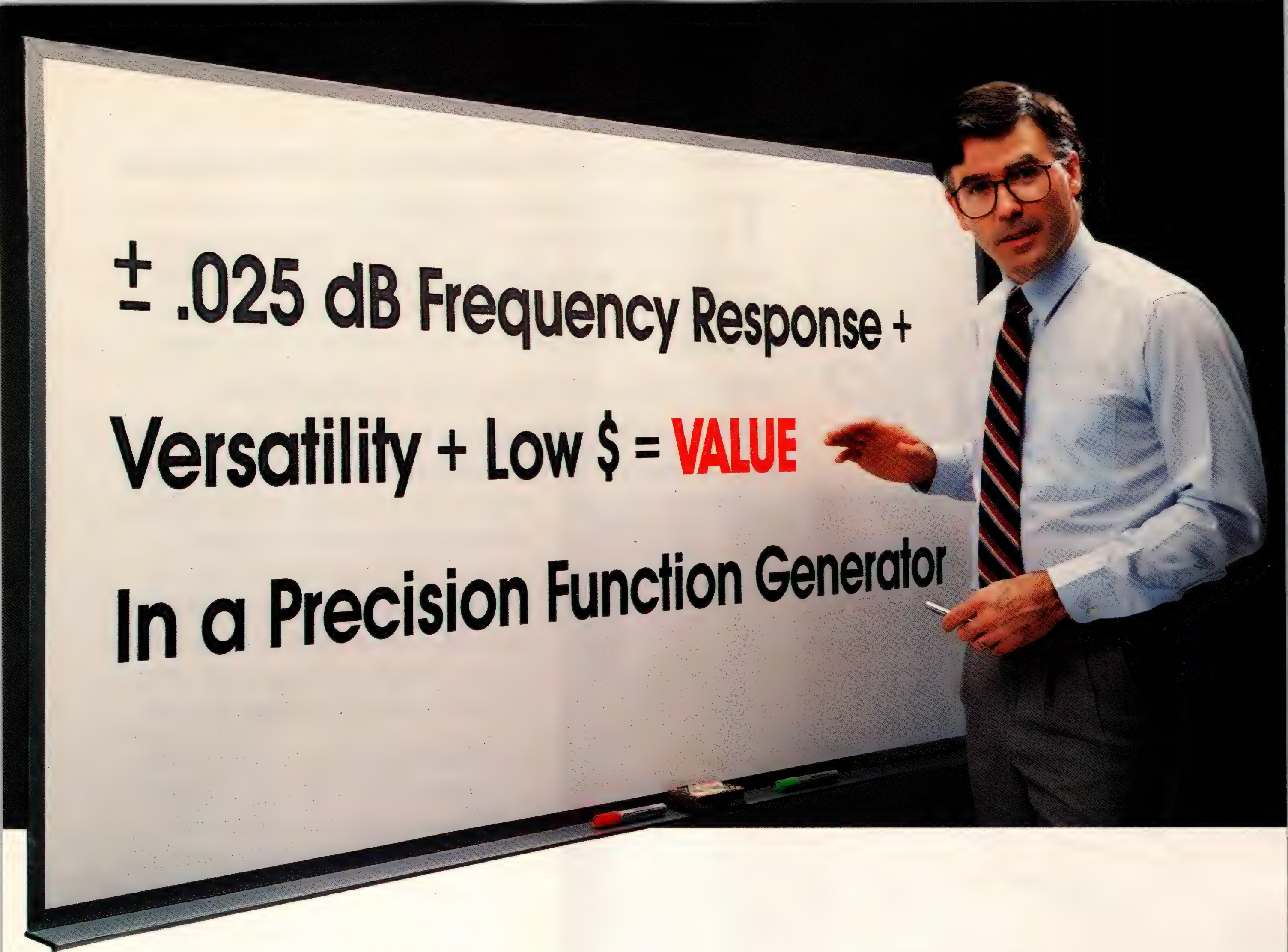

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Fourier technique lets μPs synthesize complex waveforms

Today's μPs are fast enough to generate a variety of waveforms by using Fourier synthesis. The helpful tips presented here can speed the run time of your subroutines and help you avoid some pitfalls when designing the hardware.

Lee J Schugel, *Schugel Engineering*

Applications such as automatic test equipment, environmental simulators, built-in-test circuits, and drives for robotic motors require easily adjustable complex waveforms. To generate such waveforms, designers have often relied on specialized test equipment or complex DSP-based designs. Today's single-chip μCs and highly integrated μPs, however, are fast enough and powerful enough to synthesize low-frequency (hertz to kilohertz-range) complex waveforms in a microcoded subroutine by using the Fourier technique. Understanding the basics of this synthesis technique will help you decide whether your application will permit you to use a μP to synthesize complex waveforms.

Fourier waveform synthesis, also known as additive waveform synthesis, relies on the fact that you can represent any periodic waveform by the sum of a series of sine waves that are harmonically related to a fundamental sine wave. Each of the sine waves has a fixed amplitude and phase relationship relative to the fundamental component. The frequencies of the individual sine waves are integer multiples of the fundamental frequency. That is, if the fundamental frequency is F, the Fourier series contains components at frequencies 2F, 3F, 4F, etc. By setting the phase angle of the fundamental component to 0, you can express the periodic waveform as:

$$R(F) = A_1 \sin(2\pi Ft) + A_2 \sin(4\pi Ft + \theta_2) + A_3 \sin(6\pi Ft + \theta_3) + \ldots,$$

where F is the fundamental frequency in Hz, A_x is the amplitude of the xth component, and θ_x is the phase angle of the xth component relative to the fundamental component's phase angle.

To obtain an accurate representation of the desired waveform, you must include as many terms in the series as possible. When you use a μP to calculate the individual terms, you must consider a number of other factors that affect the accuracy. These factors include the sampling rate, the number of data points to include in a sine-wave lookup table, the precision of the intermediate mathematical steps, and the resolution of the output D/A converter. You must decide on these items before you can write the software.

Next, you need to determine how many terms you wish to include in the series. The highest-frequency term establishes the minimum sampling rate. According to sampling theory, the highest-frequency term must be equal to or less than the Nyquist frequency,

You can represent any periodic waveform by the sum of a series of sine waves that are harmonically related to a fundamental sine wave.

which is half of the sampling frequency. For example, a sampling rate of 1 kHz means that the highest frequency term is equal to or less than 500 Hz.

Aliasing is responsible for this boundary. Because the μP generates sampled frequencies, the sampling process always generates an aliasing frequency above the Nyquist frequency for every sampled frequency generated below the Nyquist frequency. You can calculate this aliasing frequency thus:

Aliasing frequency = sampling rate − sampled frequency.

For example, if you use a 1-kHz sampling rate to generate a 300-Hz sine wave, an aliasing frequency term occurs at 700 Hz. If you attempt to generate a frequency higher than the Nyquist frequency, the calculation shows that the aliasing frequency is actually below the Nyquist frequency. For instance, if you attempt to generate a sine wave at 750 Hz with a sample rate of 1 kHz, the aliasing frequency occurs at 250 Hz. In **Fig 1**, sample points A through I describe a 250-Hz sine wave as well as a 750-Hz sine wave. When the samples are passed through a lowpass filter, the lower frequency is predominant. This effect, known as fold-over distortion, can severely affect the shape of the desired complex waveform.

The μP produces a series of digital samples at equally spaced intervals; the samples are passed to a DAC, which generates the analog waveform. The DAC's output must drive a lowpass filter, which smooths the analog waveform and removes the aliasing frequencies that occur above the Nyquist frequency. If ideal lowpass filters existed, you could place the cutoff frequency at the Nyquist frequency. Because practical lowpass filters have finite attenuation slopes, the highest frequency term created by the waveform synthesizer should be somewhat lower than the cutoff frequency. Although a filter with a sharp rolloff characteristic permits the generation of frequencies close to the Nyquist frequency, the use of a higher sampling rate relaxes the filtering requirements.

A sampling rate that is three to four times the highest generated frequency lets you design a 4-pole lowpass active filter with a single op amp. For example, if you choose a sampling rate of 1200 Hz when the highest generated frequency is 400 Hz, the Nyquist frequency is 600 Hz and the lowest aliasing frequency

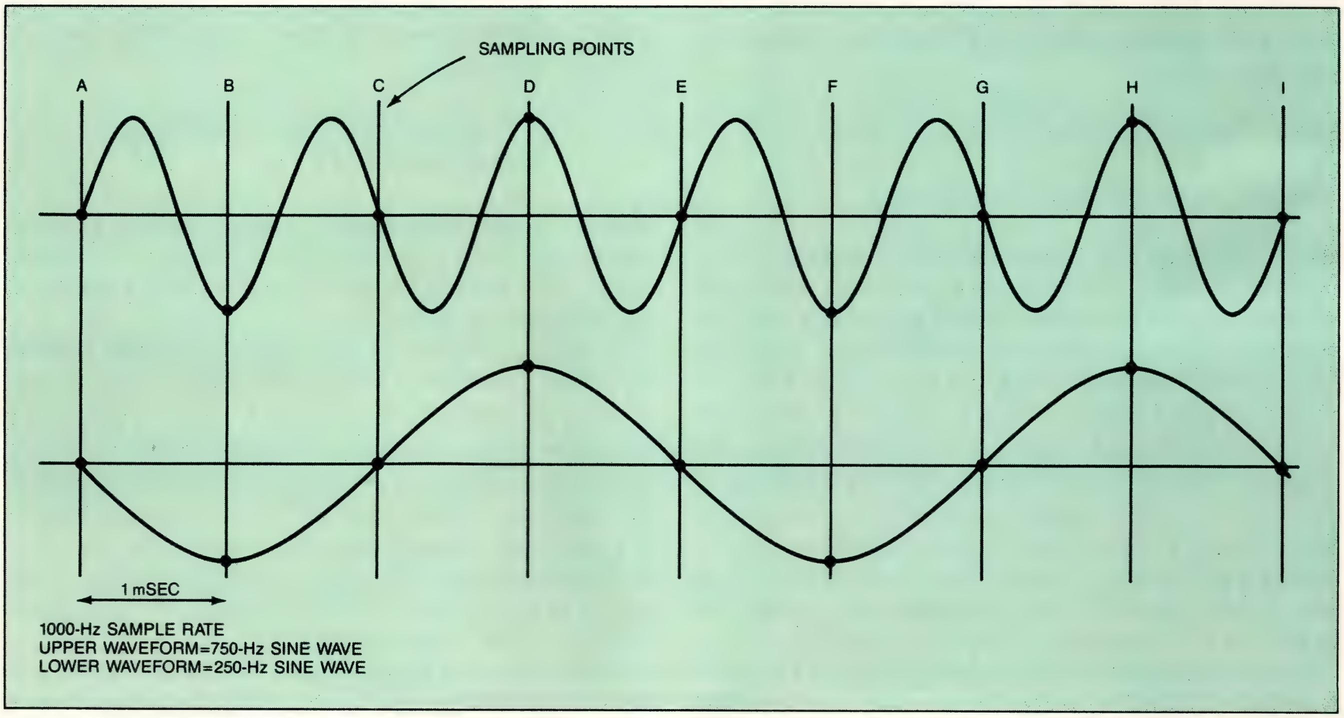

Fig 1—Aliasing produces fold-over distortion when the sampling rate is less than 2 times the Nyquist frequency. *When a 750-Hz sinewave is sampled at 1 kHz, the sample points also describe the 250-Hz aliasing frequency, which predominates when the sampled waveform passes through a lowpass filter.*

is 800 Hz. This arrangement provides a 200-Hz (or 33%) margin between the highest generated frequency and the Nyquist frequency. You can place the cutoff frequency between 400 and 600 Hz and still provide adequate attenuation at the lowest aliasing frequency—800 Hz.

A lookup table generates all of the components

Once you've selected a sample rate on the basis of the above considerations, you must decide on an algorithm for generating the components of the synthesized waveform. The digital-oscillator algorithm discussed here uses a modulo-N counter for addressing a sine-wave lookup table. The lookup table consists of N samples, which represent one complete cycle of a sine wave. You access the data in the lookup table by adding a table pointer to the lookup table's base address. The algorithm generates different frequencies by accessing only selective samples of the data in the lookup table. Because the time between selected samples must be a multiple of the sampling period, you must translate the desired frequency to a number in order to increment the table. The algorithm adds the value of the table increment to the table pointer to obtain the address of the selected sample.

For example, if the table length is 256 bytes and the sample rate is 1024 Hz, a table-increment value of 1 causes the algorithm to scan the lookup table four times each second, producing a 4-Hz sampled sine wave. Increasing the value of the table increment to 2 produces an 8-Hz sampled sine wave, and so on. You can calculate the table increment with this formula:

$$\text{Table increment} = \text{output frequency} \times \text{table length} \div \text{sample rate.}$$

Because you establish the table length and sampling rate before using the algorithm, you can compile the ratio of table length to sample rate as a constant, thus speeding the run-time calculations. You can further improve the run-time speed by creating an array of output frequency vs table increment during an initialization period, so that the algorithm's only task during run time is to find the table increment in the array.

Choose a convenient table length

The table length affects the number of calculations the software must perform, as well as the resolution of the generated waveform. A table containing 256 entries is a convenient length to use when the table increment is an 8-bit integer. It lets you add the table increment to the 16-bit table pointer by using an 8-bit ADD instruction without affecting the most significant byte of the pointer. By employing modulo-256 addition, the algorithm automatically calculates the next table address when an overflow occurs. For instance, assume the table's starting address is C000H and its ending address is C0FFH. If the table increment is 09H, the sequence proceeds as C000H, C009H, C012H, . . . C0FCH before the addition overflows. The next address after the overflow is C005H, which addresses the correct sample as if the table contained a continuous sine wave **(Fig 2.)**

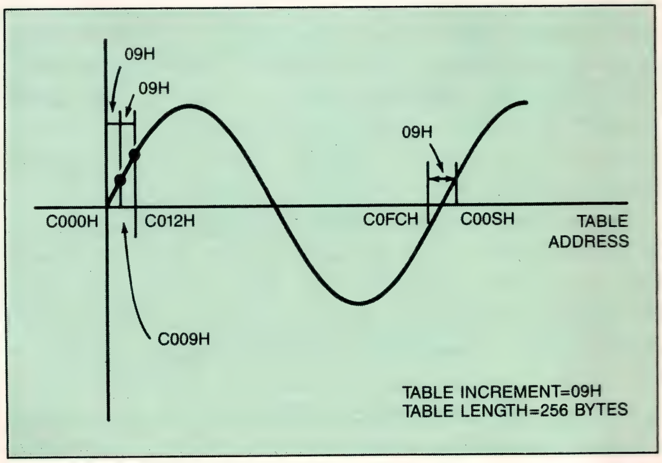

Fig 2—If you choose a 256-byte table length and use modulo-256 addition *to add the table increment to the table pointer, you don't have to adjust the sample points when the addition overflows.*

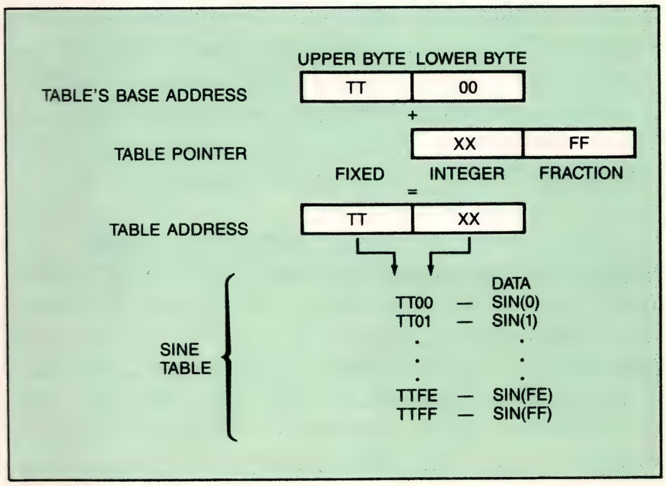

Fig 3—Placing the table's base address on a 256-byte boundary in the system's memory *lets you add the table pointer to the base address by using a logical OR statement, which is faster than an ADD statement.*

LISTING 1

```
100 '*** SINE TABLE GENERATION PROGRAM ***
110 '
120 'THIS PROGRAM GENERATES SINE WAVE LOOKUP TABLE FOR ANY ARBITRARY
130 'TABLE LENGTH. THE SINE WAVE DATA IS GIVEN IN 8-BIT 2'S-COMPLEMENT
140 'FORMAT AND ALL RESULTS ARE GIVEN IN HEX.
150 '
160 CLS : PRINT "*** Sine Wave Lookup Table ***" : PRINT
170 PRINT "          HEX" : PRINT "Step ——— Value"
180 '
190 TLEN = 256                          'DEFINE TABLE LENGTH
200 TINC = 6.28318 / TLEN 'CALCULATE TABLE STEP INCREMENT IN RADIANS
210 '
220 FOR N = 0 TO TLEN-1
230 N1 = SIN(N * TINC)                  'CALCULATE SINE FOR CURRENT STEP
250 N2 = INT((N1*127)+.499999)          'NORMALIZE RESULT IN -127 TO +127 RANGE
260 '
270 N$ = HEX$(N)                        'CONVERT STEP NUMBER TO HEX
280 IF LEN(N$) = 1 THEN N$="0"+N$       'MAKE IT 2 DIGITS IF ITS ONLY 1
290 N2$ = HEX$(N2)                      'CONVERT RESULT TO HEX
300 IF LEN(N2$)=1 THEN N2$="0"+N2$      'MAKE IT 2 DIGITS IF ITS ONLY 1
310 N2$ = RIGHT$(N2$,2)                 'KEEP ONLY 2 RIGHT DIGITS
320 PRINT N$;TAB(12);N2$                'PRINT STEP NUMBER AND RESULT
330 NEXT N
340 END
```

If the table contains 256 entries, you should locate the table on a 256-byte boundary in the system's memory. By so doing, you can fix the upper byte of the table's 16-bit address and add the pointer to the lower byte of the table's base address when accessing the data (**Fig 3**). Because the lower byte of the table's base address is 00H, you can perform the addition with a logical OR statement, which executes more quickly than an ADD statement.

Although you can use any table length, the software for checking overflow is simpler when the table is a binary multiple (512, 1024, etc). If you choose a table length of 1024 bytes (400H), it's easier to check for overflow when the table's starting address is x000H or x800H than when it's x400H or xC00H. For example, if the starting address of a 1024-byte table is C000H, the last byte in the table is located at C3FFH. Adding a table increment of 1 to this last address causes the table address to increase to C400H. It's always a simple matter to clear the third bit in the upper byte of the table pointer in software to obtain the desired address, C000H. Essentially, it's faster to clear this bit on each addition than it is to check to see if an overflow occurred. In any case, however, you must still use 16-bit arithmetic, because the table length is greater than 256. **Listing 1** generates a sine-wave lookup table for an arbitrary table length.

When calculating the table increment, you must provide a method for handling fractional increments. For example, if you wish to generate a 6-Hz sine wave by using a 256-byte table and a sampling rate of 1024 Hz, you'll find that the formula calls for a table increment of 1.5. A simple way to handle this situation is to treat the most significant byte of a 16-bit table pointer as the integer part and the least significant byte as the fractional part. This pointer now has a resolution of 1 part in 256. Using this method, you must multiply the table increment value that the formula calculates by 256.

Because the 16-bit table pointer has greater precision than the number of samples in the lookup table (256), in order to use the pointer you must lop off some of its bits. There are essentially three different ways to accomplish this goal, each providing varying degrees of precision at the expense of calculation time. The first (and simplest) way is to divide the table pointer by a constant and truncate the result. In this example, you divide by 256 by simply discarding the least significant byte of the 16-bit table pointer.

The second method, which is slightly more difficult, is to divide the table pointer by the same constant, but round the result to the nearest integer. This method requires that you use the most significant bit in the pointer's least significant byte when calculating the table address. You then use only the upper byte to address the lookup table. Rounding to the nearest integer provides a more accurate output waveform with less distortion, but requires an additional calculation before you can look data up in the table.

The third way to handle rounding is interpolation,

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To obtain an accurate representation of the desired waveform, you must include as many terms in the series as possible.

which is much more difficult. This method produces the most accuracy, but the price—additional calculations—is significant. Interpolation requires the algorithm to read two samples from the table for each increment. It must read the data at the current table address and the data at the next table address. It then multiplies the difference between the sampled points by the fractional part of the pointer and adds the result to the current sample. Generally, it's easier to increase the table length to achieve more accuracy than it is to provide the mathematical overhead required for interpolation.

Before the algorithm generates the Fourier series, it must also calculate the phase angle of the individual components. In the digital-oscillator algorithm, the phase angle is simply an offset that is added to the table pointer before data is accessed in the lookup table. The software must convert the phase angle (which is expressed either in degrees or in radians) to a table-offset number by using one of the following formulas:

$$\text{Table offset} = \text{table length} \times \text{phase angle (degrees)}/360$$

or

$$\text{Table offset} = \text{table length} \times \text{phase angle (radians)}/2\pi.$$

For waveforms with fixed phase angles, the table pointer can be initialized to the table offset value before the algorithm generates the sine wave.

The algorithm must also adjust the relative amplitudes of the components before generating the series. Many μCs and μPs include a multiply instruction in their instruction sets. The most common (and usually the fastest) multiply instruction produces a 16-bit resultant by multiplying two unsigned 8-bit quantities. Multiplying the 8-bit samples in the lookup table by an 8-bit multiplier produces the 16-bit resultant. When you treat the multiplier as a fraction in the range between 0 and 255/256, the most significant byte of the resultant is the scaled amplitude.

When using an unsigned multiply instruction, you must include software for handling negative quantities. When two's-complement data is read from the lookup table, the software must check the sign bit to determine whether the data is negative. If it is negative, the software must convert it to positive data, perform the unsigned multiplication, and convert the resultant to negative data. If the sign bit indicates that the data is positive, no adjustment is necessary.

The algorithm adds the resultant for each of the samples to a running sum to calculate the Fourier series. Because each sample produces a signed 8-bit resultant, the running sum must have greater than 8-bit precision. A 16-bit register is sufficient for most applications, because it's large enough to handle the resultants for 256 samples without data overflow.

You must still choose the resolution of the DAC for your particular application. The vectorial sum drives the DAC to generate the complex analog waveform. A DAC with a resolution of 16 bits provides a maximum dynamic range of 96 dB. The maximum dynamic range (and, inherently, the maximum S/N ratio) is simply 6 dB times the number of bits of DAC resolution. A DAC with 8 bits of resolution produces a waveform with a maximum S/N ration of 48 dB. If your application anticipates large swings in amplitude or requires a large number of harmonic terms, you may want to choose a DAC with greater resolution than that of the data in the lookup table. The decision is essentially a cost/performance tradeoff.

Once you've decided on the DAC's resolution, you must scale the vectorial sum to conform to the DAC's constraints. To avoid catastrophe, you should symmetrically limit the digital data so that the signal doesn't exceed the DAC's capabilities. Because the vectorial sum is a signed quantity that can be positive or negative, the software must calculate the symmetrical clipping limits on the basis of the sign bit for two's-complement data. If you were simply to truncate the data to conform to the DAC's constraints, it would be possible for a negative quantity to be converted to a positive quantity, a situation that could wreak havoc when the complex waveform synthesizer is driving real-world hardware. **EDN**

Author's biography

Lee J Schugel is president of Schugel Engineering, a consulting firm in Brandon, FL. Lee has worked as a consultant for 10 years; he specializes in digital, μP, and software product development and enhancement. Previously, he was employed by CASE Communications Inc. He received a BSEE from the University of South Florida in 1976. Lee is a member of the Tau Beta Pi engineering honor society. In his spare time he plays keyboard instruments and watches auto racing.

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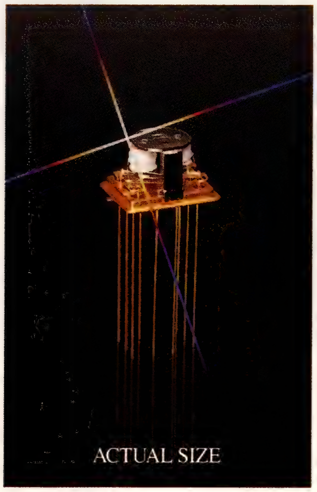

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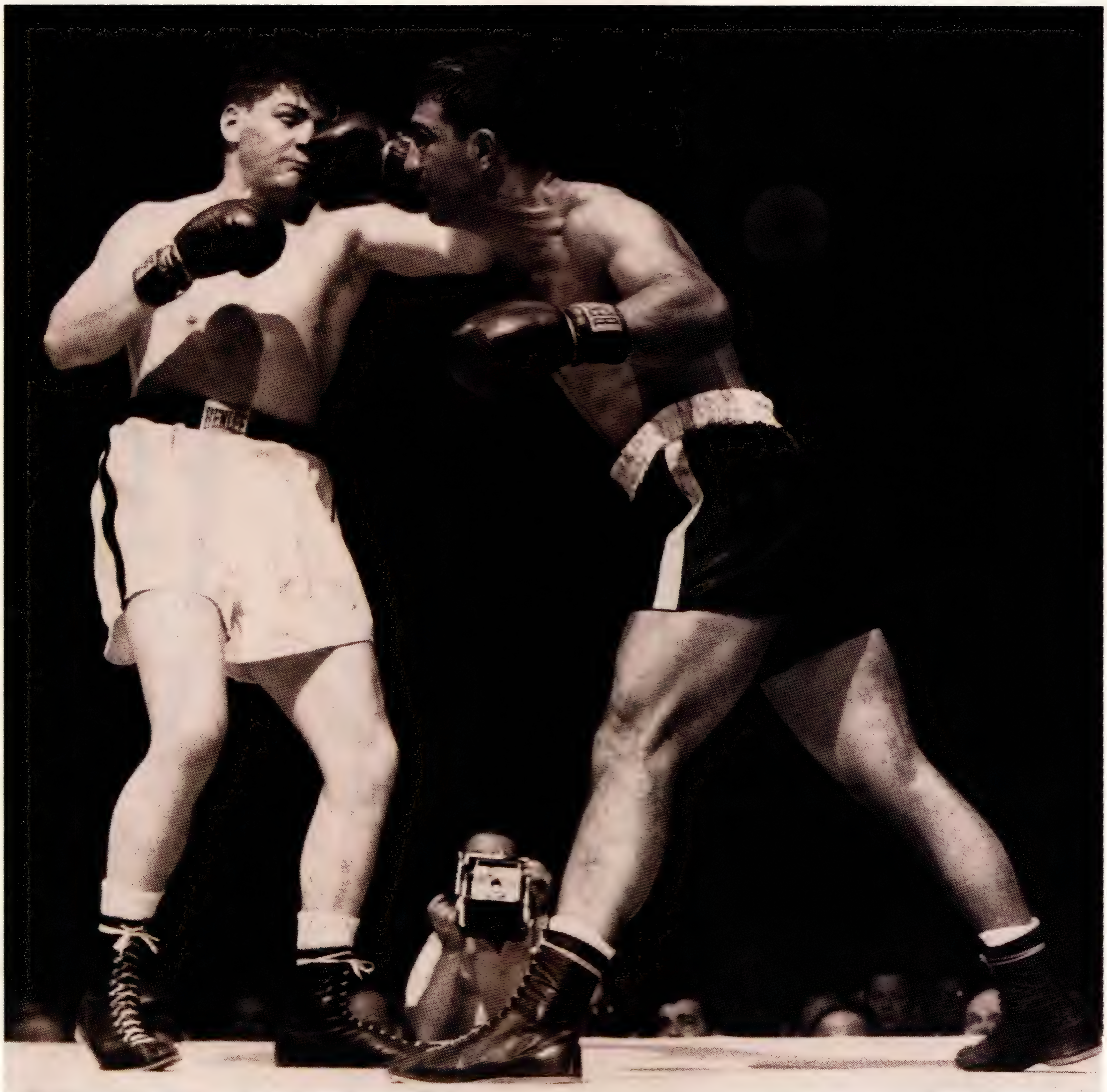

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ZPS-250-N	250	4.75/5.25	3.5/35.0	10.0/15.5	0.4/4.0 PK6	10.0/15.5	0.4/4.0 PK6	4.75/5.25	0.3/3.0	5.0 x 2.5 x 13
ZPS-300-N	300	4.75/5.25	4.5/45.0	10.0/15.5	0.8/8.0 PK12	10.0/15.5	0.8/8.0 PK12	4.75/5.25	0.4/4.0	5.0 x 2.5 x 13
ZPS-400-N	400	4.75/5.25	5.5/55.0	10.0/15.5	1.0/10.0 PK15	10.0/15.5	1.0/10.0 PK15	4.75/5.25	0.6/6.0	6.0 x 2.5 x 13

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CIRCLE NO 145

DESIGN NOTES

Number 5 in a series from Linear Technology Corporation March, 1989

Temperature Measurement Using the LTC1090/91/92 Series of Data Acquisition Systems

William Rempfer
Guy Hoover

Introduction

Accurate temperature measurement is a difficult and very common problem. Whether recording a temperature, regulating a temperature or modifying a process to accommodate a temperature, the LTC1090 family of data acquisition systems can provide an important link in the chain between the blast furnace temperature and the microcontroller. Features of the LTC1090 family can make temperature measurement easier, cheaper and more accurate.

High DC input resistance and reduced span operation allow direct connection to many standard temperature sensors. Multiplexer options allow one chip to measure up to 8 channels of temperature information. Single supply operation, modest power requirements (~5mW) and serial interfaces make remote location possible. Switching power on and off lowers power consumption (560μW) even more for battery applications. Finally, because few sensors have accuracies as good as 0.1%, the 10-bit resolution and 0.05% accuracy of the LTC1090 family are just right for most temperature sensing applications.

Thermocouple Systems

The circuit of Figure 1 measures exhaust gas temperature in a furnace. The 10-bit LTC1091A gives 0.5°C resolution over a 0°C to 500°C range. The LTC1050 amplifies and filters the thermocouple signal, the LT1025A provides cold junction compensation and the LT1019A provides an accurate reference. The J type thermocouple characteristic is linearized digitally inside the MCU. Linear interpolation between known temperature points spaced 30°C apart introduces less than 0.1°C error. The code for linearizing is available from LTC. The 1024 steps provided by the LTC1091 (24 more than the required 1000) insure 0.5°C resolution even with the thermocouple curvature.

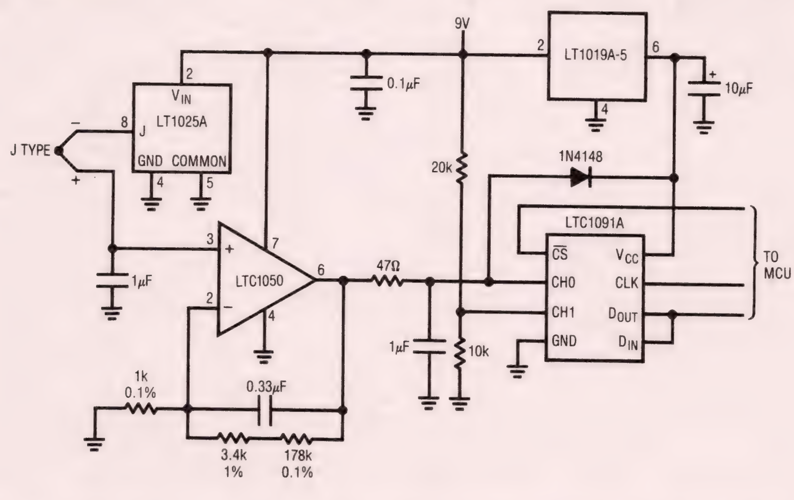

Figure 1. 0°C-500°C Furnace Exhaust Gas Temperature Monitor with Low Supply Detection

Offset error is dominated by the LT1025 cold junction compensator which introduces 0.5°C maximum. Gain error is 0.75°C max because of the 0.1% gain resistors and to a lesser extent the output voltage tolerance of the LT1019A and the gain error of the LTC1091A. It may be reduced by trimming the LT1019A or gain resistors. The LTC1091A keeps linearity better than 0.25°C. The LTC1050's 5μV offset contributes negligible error (0.1°C or less). Combined errors are typically 0.5°C or less. These errors don't include the thermocouple itself. In practice, connection and wire errors of 0.5°C to 1°C are not uncommon. With care, these errors can be kept below 0.5°C.

The 20k/10k divider on CH1 of the LTC1091 provides low supply voltage detection (the LT1019A reference requires a minimum supply of 6.5V to maintain accuracy). Remote location is easy, with data transferred from the MCU to the LTC1091 via the 3 wire serial port.

Thermilinear Networks

Figure 2 shows an 8 channel 0°C to 100°C temperature measurement system with 0.1°C resolution. The high DC input resistance and adjustable span of the LTC1090 allow it to measure the outputs of the YSI thermilinear components directly. Accuracy is limited by the sensor repeatability and precision resistors to 0.25°C.

Sensor input voltage (V_{IN}), not critical because of ratiometric operation, is set to around 1.5V to minimize self heating. The zero scale (COM pin) and full-scale (REF^+ pin) of the LTC1090 are set by the precision resistor string to directly digitize the roughly 0.2V to 1V sensor output. The LT1006 buffers the 10kΩ reference resistance of the LTC1090. 0°C and 100°C correspond to unipolar output codes of 0 and 1000 (decimal), respectively with an overrange of 102.3°C.

Thermistors

A thermistor is a cheaper alternative to thermilinear components in narrower temperature range applications. In Figure 2, CH7 is being used to digitize the output of a 5kΩ thermistor. The resistor shown linearizes the output voltage around the 30°C point. The output remains linear to 0.1°C over a 20°C to 40°C range but gets nonlinear rapidly outside this range. By correcting for the non-linearity in software this range can be extended to 0°C to 60°C. Beyond that, the repeatability error of the thermistor increases above 0.2°C making correction difficult.

Silicon Sensors

Because of its high DC input impedance and reduced span capability, the LTC1090 family can directly measure the output of most industry standard silicon temperature sensors, both voltage and current mode. Popular sensors of this type include the LM134 and AD590 (current output) and silicon diodes.

Figure 3 shows a simple connection between the LTC1092 and industry standard 1μA/°K current output sensors. Resolution is 0.25°C and accuracy is limited by the sensor and resistors. Standard 10mV/°K voltage output sensors can also be connected directly to the LTC1092 input in a similar manner.

For LTC1090/91/92 literature call **800-637-5545.** For help with an application call (408) 432-1900, Ext. 361.

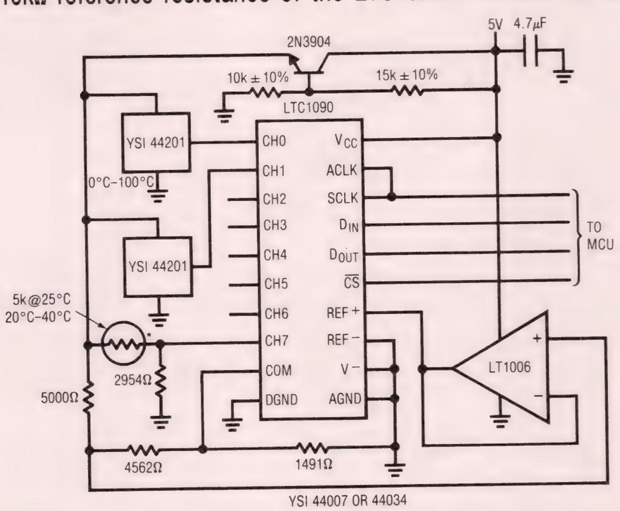

Figure 2. 0°C-100°C 0.25°C Accurate Thermistor Based Temperature Measurement System

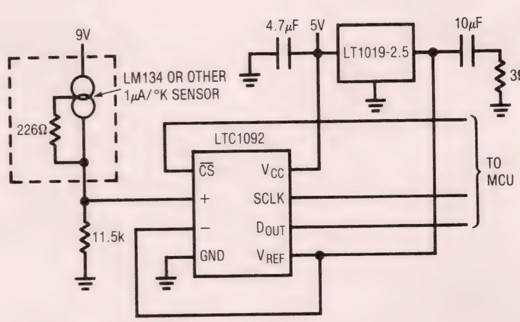

Figure 3. −55°C to +125°C Thermometer Using Current Output Silicon Sensors

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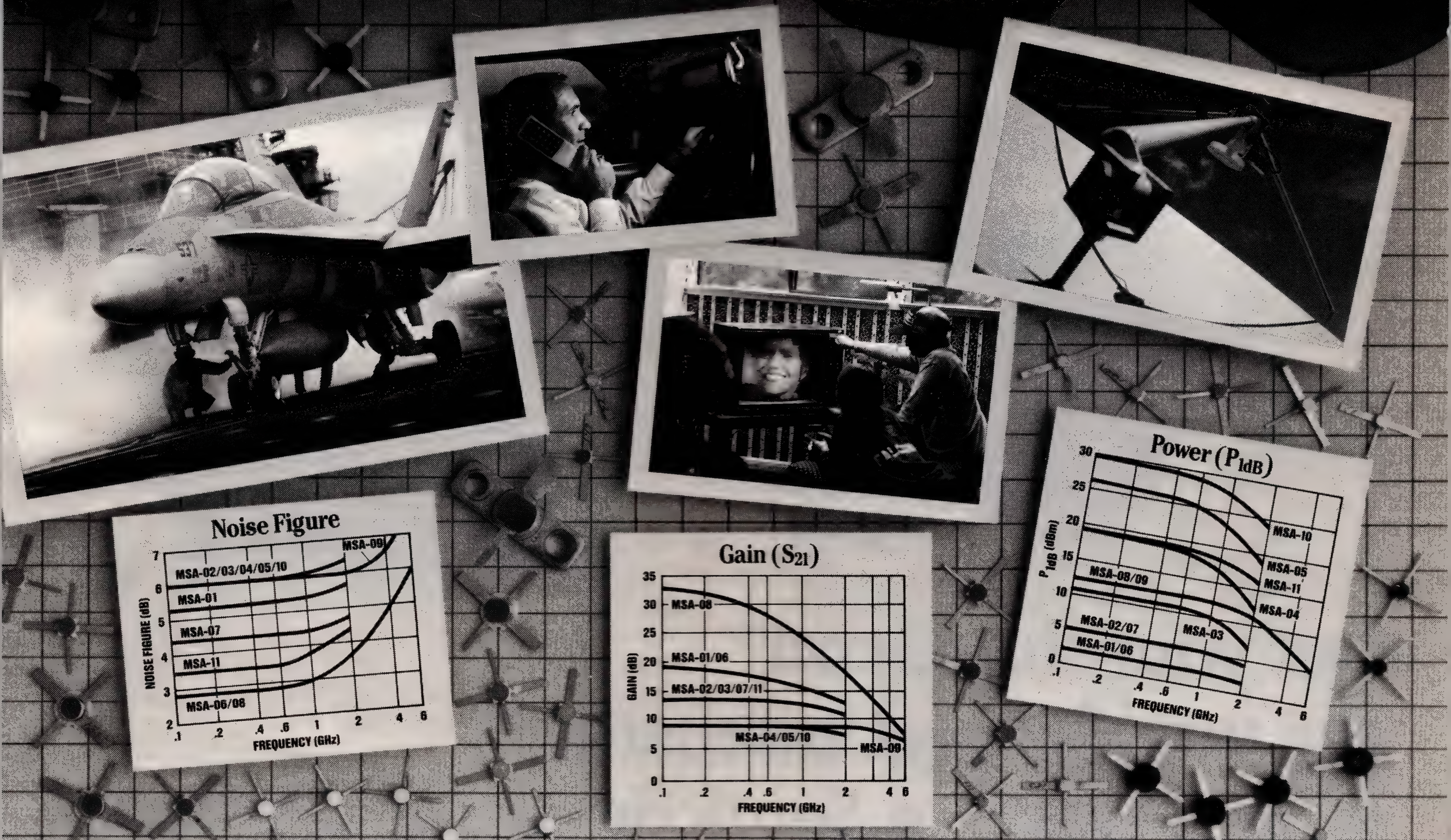

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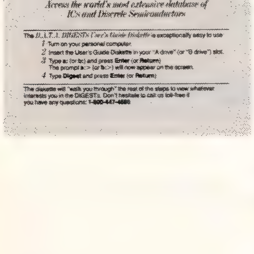

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Divider displays uncanny accuracy

Michael A Wyatt
SSAvD Honeywell Inc, Clearwater, FL

The voltage divider in **Fig 1** divides V_{REF} in half with uncanny accuracy yet uses no precision components. Note that unlike dividers based on precision resistors, which can divide a voltage in virtually any proportion, this circuit will only divide V_{REF} in half.

The circuit uses a CMOS flip-flop to toggle the divider resistors, R_1 and R_2, between V_{REF} and ground. R_1 and R_2 need not be precision resistors because the toggling action, along with C_1, averages any error toward zero.

To better understand the operation of this circuit, consider **Fig 2.** In **Fig 2a,** the flip-flop's Q output is high and R_1 and R_2 (along with the flip-flop's output transistors' on-resistances, R_P and R_N) form a simple voltage divider. When the flip-flop changes state, R_1 and R_2, in effect, exchange their positions on the voltage-divider totem pole.

Because the effects of the flip-flop's output transistors' on-resistances and any mismatch between R_1 and R_2 tends to average out, the major source of inaccuracy in this circuit is asymmetry in the flip-flop's time division. You could further improve the accuracy of this circuit by buffering the Q and $\overline{Q}$ outputs with an HC-type line driver with paralleled outputs. This device would further reduce the effects of the flip-flop's output transistors' on-resistances. EDN

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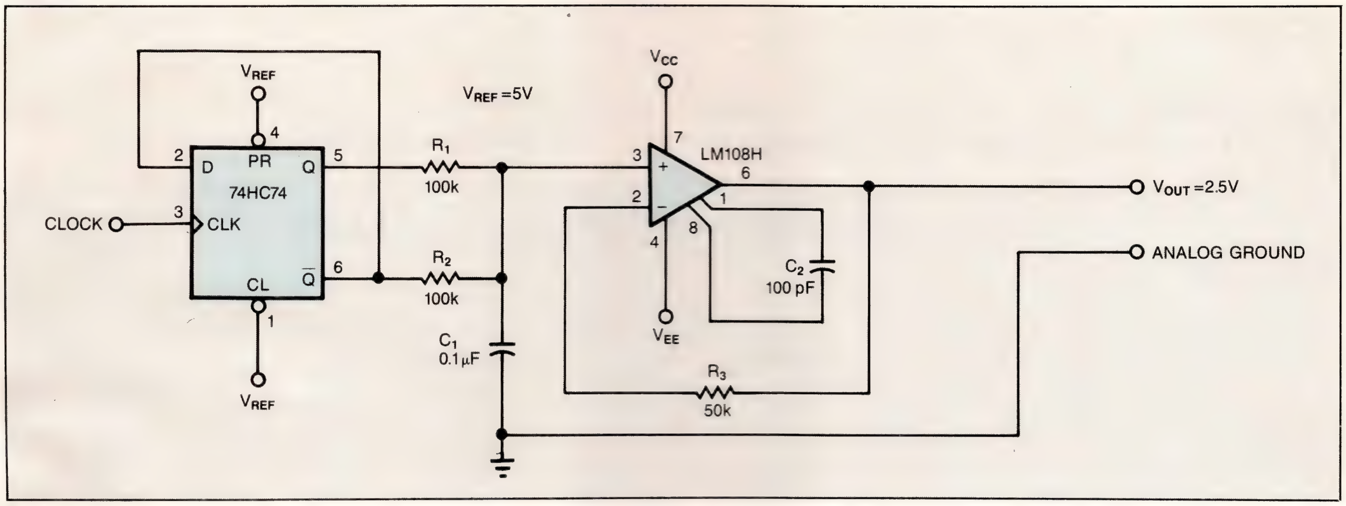

Fig 1—This circuit divides V_{REF} in half precisely yet uses no precision components.

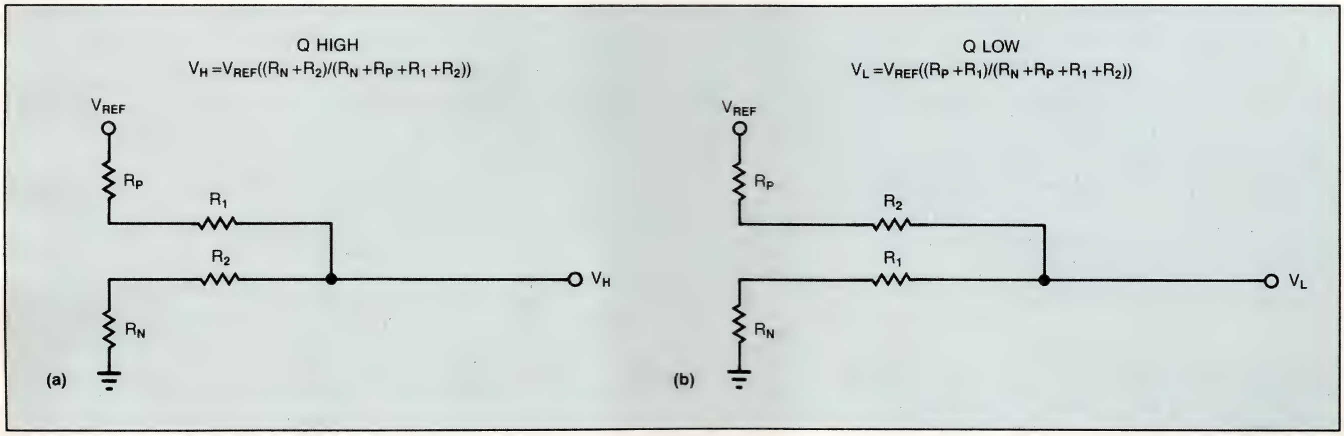

Fig 2—The flip-flop in Fig 1 reverses the order of R_1 and R_2 between V_{REF} and ground developing, alternately V_H (a) and V_L (b). The capacitor C_1 averages V_H and V_L, which yields a voltage precisely half that of V_{REF}.

Algorithm computes standard values

Manfred A Levigion
VDO Luftfahrtgerate, Frankfurt, West Germany

The BASIC routine in **Listing 1** can make programs that use standard-tolerance component values smarter. You can easily redirect the routine's input commands to transform it into a subroutine that you could incorporate into your programs. Thus, instead of looking up standard values in a table, your programs can calculate them.

The routine follows the IEC standard for designating tolerances. However, a glance at the routine's heading will make the relationship between the IEC standard's use of an "E" number and tolerances clear.

The routine calculates standard values according to the formula

$$R_n = 10^{(n-1)/E},$$

where E equals 6, 12, 24 . . . according to the tolerance range needed and n is the index of the component in the series. The real trick with this formula is truncating the results and dealing with logarithms.

Line 180 computes a factor that will increase the component value you have supplied, RX, by half its tolerance, so that later truncation will yield the correct answer. Line 210 calculates the logarithm of the input value RX. If your version of BASIC has the LOG10 command, change line 210 to SC = LOG10(RX).

Lines 220 through 240 calculate the exponent portion of the formula and take the antilog of the resulting value. Note that the IEC E24 standard does not follow this formula exactly. For example, the IEC E24 standard specifies 1.3, 1.5, and 1.6 as standard values. However, the IEC E96 standard, which should be proportional to the E24 standard, specifies three steps between 1.5 and 1.6 and six steps between 1.3 and 1.5. EDN

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LISTING 1—STANDARD-VALUE COMPONENT CALCULATOR

```
00010 REM------------------------------------------------------------------
00020 REM
00030 REM CALCULATION OF ELECTRONIC COMPONENTS ACCORDING THERE
00040 REM TOLERANCE STANDARDS
00050 REM
00060 REM E6  = 20%
00070 REM E12 = 10%
00080 REM E24 = 5%  (INCORRECT)
00090 REM E48 = 2%
00100 REM E96 = 1% etc.
00110 REM
00120 REM BY MANFRED A. LEVIGION
00130 REM
00140 REM--------------------------------------------------------------
00150 INPUT " TO WHICH TOLERANCE STANDARD SHALL BE CALCULATED",E
00160 N=2
00170 IF E<25 THEN N=1
00180 E2 = 10^(1/(2*E))
00190 INPUT " VALUE FOR EVALUATION ",RX
00200 RX=RX*E2
00210 SC=LOG(RX)/LOG(10)
00220 SCF=INT(SC)          !GET MULTIPLIER
00230 RE=INT((SC-SCF)*E)/E
00240 RZ=INT(10^(N+RE)+.5)*10^(SCF-N)
00250 PRINT " STANDARD VALUE : ";RZ
00260 INPUT " AGAIN (Y/N) ",Z$
00270 IF Z$="Y" OR Z$="y" THEN GOTO 190
00280 END
```

Program limits thermistor nonlinearity

G Fleeger
Hughes Aircraft Co, Los Angeles, CA

Connecting a resistor in series and another in parallel with a thermistor (**Fig 1**) will improve the thermistor's linearity at the expense of a smaller range of resistance change with temperature. The BASIC program in **Listing 1** lets you specify the resistance change needed over your temperature range. The program then selects optimal values for these 1% resistors in less than one second.

The program solves a set of equations for resistor values that will make the network's resistance vary equally between the median and each endpoint temperature by your specified percentage. The program also calculates the values of the 1% resistors rather than look them up in a table. You should be able to adapt this program to other types of nonlinear resistors. EDN

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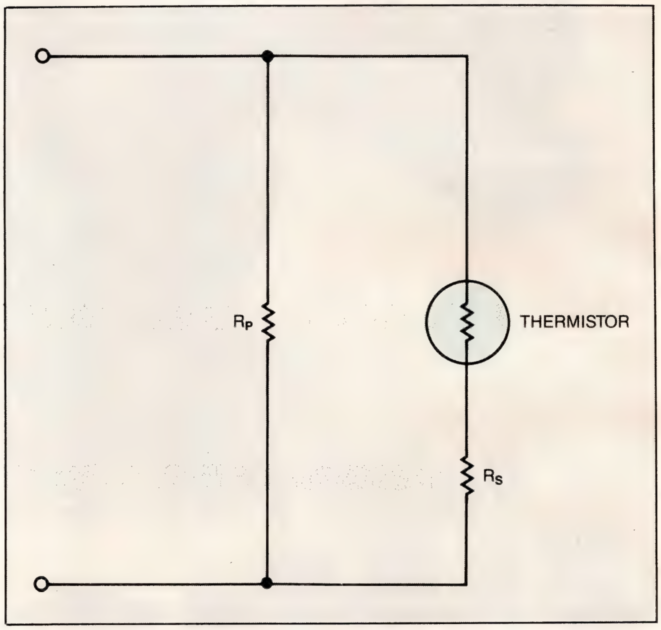

Fig 1—Adding a series and parallel resistor to *an NTC thermistor improves its linearity.*

LISTING 1—THERMISTOR LINEARIZATION PROGRAM

```
10 '********************************* DATA INPUT *******************************
20 CLS :DEFSNG A-Y
30 INPUT "ENTER THE THERMISTOR RESISTANCE AT THE COLD TEMPERATURE ",TC
40 INPUT "ENTER THE THERMISTOR RESISTANCE AT THE MEDIAN TEMPERATURE ",TM
50 INPUT "ENTER THE THERMISTOR RESISTANCE AT THE HOT TEMPERATURE ",TH
60 IF TH < TM AND TH < TC AND TM < TC THEN 70 ELSE 490
70 IF (TC+TH)/2 > TM THEN 90 ELSE 510
80  '
90  '****************************** CALCULATIONS ******************************
100 '
110 K=(TC*TM+TH*(TM-2*TC))/(TC+TH-2*TM) :MP=((K*(TC-TM)/(TM*(K+TC)))-.0005)*100
120 PRINT
130 PRINT "THE MAXIMUM EQUAL PLUS AND MINUS CHANGE IS";MP;"PERCENT"
140 INPUT "ENTER THE DESIRED PLUS AND MINUS PERCENTAGE CHANGE ",DP
150 IF DP > MP+.00001 THEN 130 ELSE 170
160 '
170 DP=DP/100 :RS=(TM*(K+DP*(K+TC))-K*TC)/(TM-(TC+DP*(K+TC))) :RP=K-RS
180 CR=(TC+RS)*RP/(TC+K) :MR=(TM+RS)*RP/(TM+K) :HR=(TH+RS)*RP/(TH+K)
190 R=RS :GOSUB 400 :RSV=R :R=RP :GOSUB 400 :RPV=R
200 '
210 '*** ALTERNATIVELY, R=RP IN THE ABOVE LINE COULD BE CHANGED TO R=K-RSV ***
220 '*** TO OPTIMIZE SELECTION OF RP BASED ON CLOSEST STANDARD VALUE OF RS ***
230 '
240 '****************************** DATA OUTPUT ******************************
250 PRINT
260 PRINT "THE SERIES RESISTANCE SHOULD BE EXACTLY";RS;"OHMS"
270 PRINT "THE PARALLEL RESISTANCE SHOULD BE EXACTLY";RP;"OHMS"
280 PRINT
290 PRINT "THE NETWORK RESISTANCE AT THE COLD TEMPERATURE IS";CR;"OHMS"
300 PRINT "THE NETWORK RESISTANCE AT THE MEDIAN TEMPERATURE IS";MR;"OHMS"
310 PRINT "THE NETWORK RESISTANCE AT THE HOT TEMPERATURE IS";HR;"OHMS"
320 PRINT
330 PRINT "RESISTANCE CHANGE FROM THE MEDIAN TO COLD IS ";CR-MR;"OHMS"
340 PRINT "RESISTANCE CHANGE FROM THE MEDIAN TO HOT  IS ";HR-MR;"OHMS"
350 PRINT "TOTAL RESISTANCE CHANGE FROM  HOT TO COLD IS ";CR-HR;"OHMS"
```

LISTING 1—THERMISTOR LINEARIZATION PROGRAM *(Continued)*

```
360 PRINT :P$="##.##^^^^_ " 'FORMAT REQUIRED FOR BINARY MATH VERSIONS OF BASIC
370 PRINT USING "THE CLOSEST STANDARD RESISTORS ARE"+P$+"AND"+P$+"OHMS";RSV;RPV
380 END
390 '
400 '*********** CALCULATION OF STANDARD ONE PERCENT RESISTOR VALUES **********
410 '
420 V=2.398521E-02 :W=R :X=INT((LOG(R)/LOG(10))-2) :R=R/10^X
430 FOR Z=0 TO 1 :Y[Z]=INT(EXP(V*(INT(LOG(R)/V)+Z))+.5) :NEXT Z
440 RL=(Y[0]*10^X) :RH=(Y[1]*10^X) :IF ABS(W-RL)=>ABS(RH-W) THEN R=RH ELSE R=RL
450 RETURN
460 '
470 '***************************** ERROR MESSAGES *****************************
480 '
490 PRINT :PRINT "THE RESISTANCE MUST DECREASE AS THE TEMPERATURE INCREASES"
500 PRINT :GOTO 30
510 PRINT
520 PRINT "AVERAGE OF HOT AND COLD RESISTANCES MUST BE GREATER THAN THE MEDIAN"
530 PRINT :GOTO 30
```

Counter sequences aperiodically

S Murugesan
NASA Ames Research Center, Moffett Field, CA

The counter in **Fig 1** is an improvement over the design presented in "Counter controls its own clock frequency," EDN, May 12, 1988, pg 205. This circuit is simpler, more versatile, more accurate, and more easily extended to higher numbers of bits than the earlier circuit.

Without the optional mapping PROM, counter A increments counter B each time counter A counts down to zero. Counter B, in turn, supplies counter A with a preset value that increases by one each time counter A counts to zero.

The mapping PROM extends this circuit's usefulness beyond the peculiar application described above. The mapping PROM converts a given count of counter B to an arbitrary preset for counter A. Thus, counter A can produce a repeatable series of aperiodic counts.

EDN

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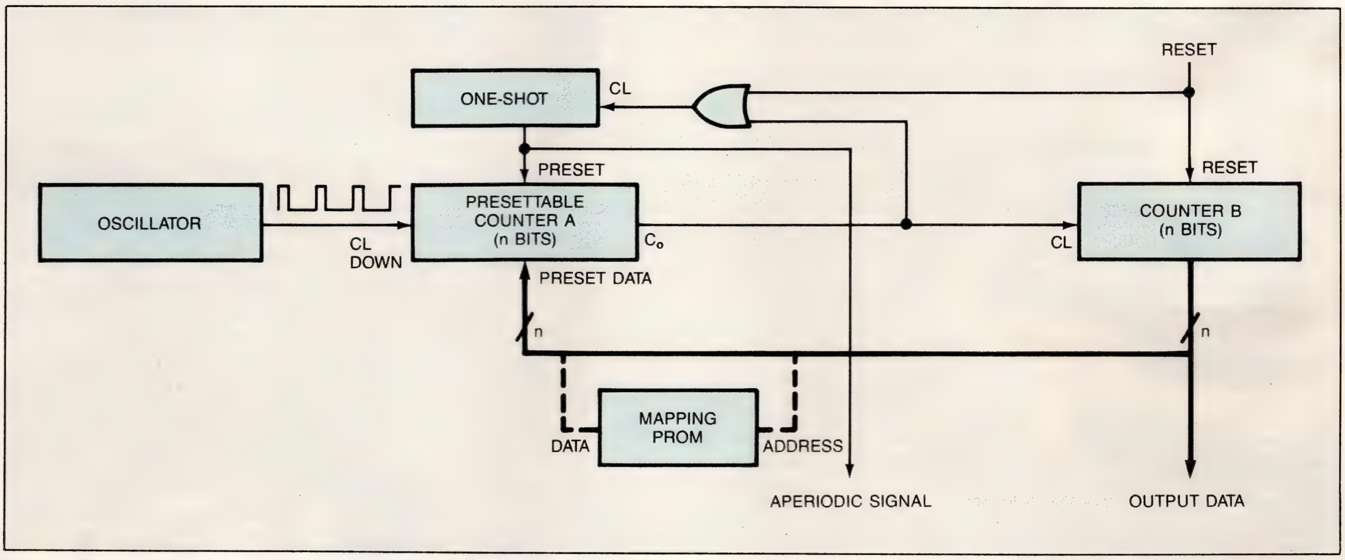

Fig 1—Counter B selects a different, arbitrary preset *value for counter A each time counter A counts to zero. Thus, counter A can produce a repeatable series of aperiodic counts.*

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Circuit cleans up noisy signals

James M Gagnon
Boeing Electronics Div, Seattle, WA

The circuit in **Fig 1** filters noise, such as glitches and contact bounce, from digital signals. You can easily adjust the circuit for a wide range of noise frequencies.

The circuit's output changes state only if the input differs from the output long enough for the counter to count up eight cycles. If the input changes before the counter reaches its maximum count, the counter resets without clocking the output flip-flop, IC_2.

You use R_2 to set the frequency of the 2-inverter CMOS oscillator, which clocks the counter. Simply adjust the oscillator such that its period is one-eighth that of the noise you want to eliminate. EDN

To Vote For This Design, Circle No 750

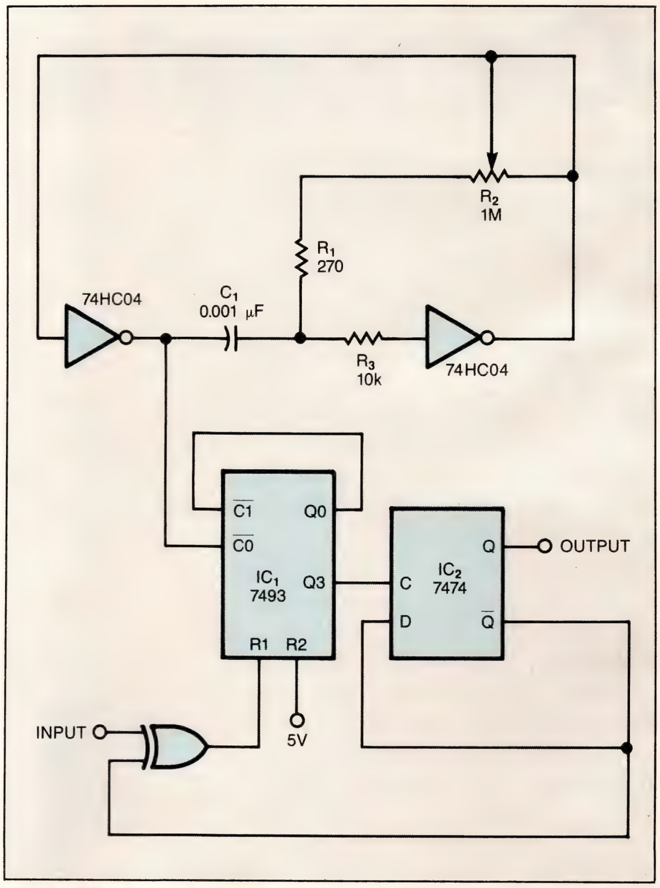

*Fig 1—**The input to this circuit must not** change state until the counter reaches its maximum count in order for the counter to clock the input through to the output.*

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WRI 3012	+12v,2.5A		
WRI 4214	+24v,1.75A		
WRI 3021	+5v,2A	+12v,1.5/2.5A	
WRI 4221	+5v,3A	+12v,2.5/4A	
WRI 3031	+5v,2A	+12v,1.5/2.5A	—12v,.5A
WRI 4231	+5v,3A	+12v,2.5/4A	—12v,.5A

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WM144	+12v,1.2A		
WM112	+5v,800mA	+12v,600mA	
WM053	+5v,380mA	—5v,180mA	+12v,180mA
WM063	+5v,380mA	—12v,180mA	+12v,180mA
WM093	+5v,860mA	—5v,300mA	+12v,300mA
WM113	+5v,860mA	—12v,300mA	+12v,300mA
WM220-1	+5v,2.0A	+12v,500mA	—12v,500mA

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CIRCLE NO 124

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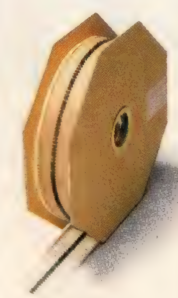

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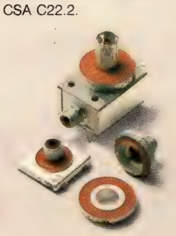
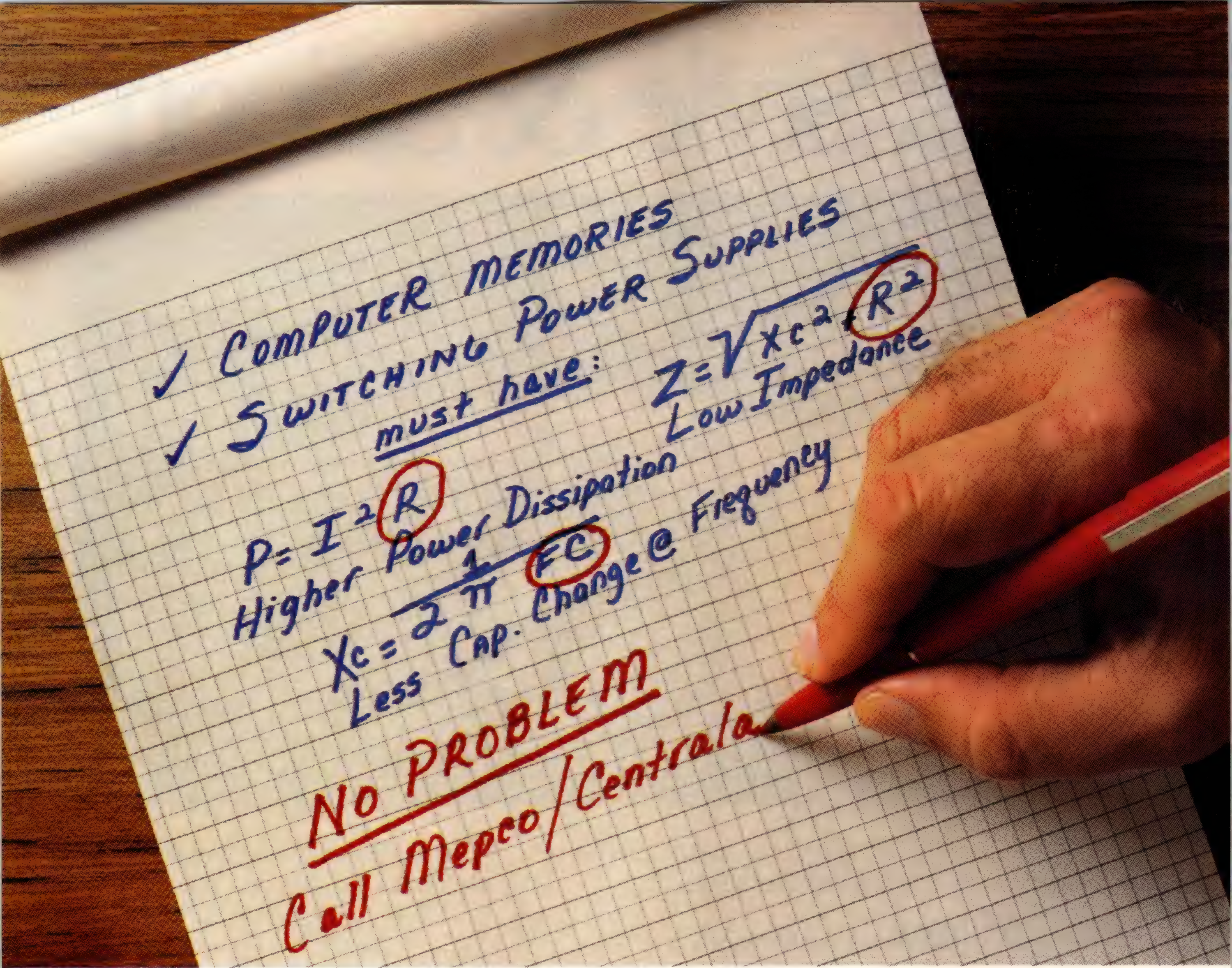


TDK

TDK CORPORATION OF AMERICA HEAD OFFICE 1600 Feehanville Drive, Mount Prospect, IL 60056, U.S.A. Phone: (312) 803-6100 CHICAGO REGIONAL OFFICE Phone: (312) 803-6100 INDIANAPOLIS REGIONAL OFFICE Phone: (317) 872-0370 NEW YORK REGIONAL OFFICE Phone: (516) 625-0100 LOS ANGELES REGIONAL OFFICE Phone: (213) 539-6631 DETROIT DISTRICT OFFICE Phone: (313) 353-9393 NEW JERSEY DISTRICT OFFICE Phone: (201) 736-0023 BOSTON DISTRICT OFFICE Phone: (508) 624-4262 HUNTSVILLE DISTRICT OFFICE Phone: (205) 539-4551 GREENSBORO DISTRICT OFFICE Phone: (919) 292-0012 DALLAS DISTRICT OFFICE Phone: (214) 506-9800 SAN FRANCISCO DISTRICT OFFICE Phone: (408) 437-9585 **TDK CORPORATION.** TOKYO, JAPAN.



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PHILIPS

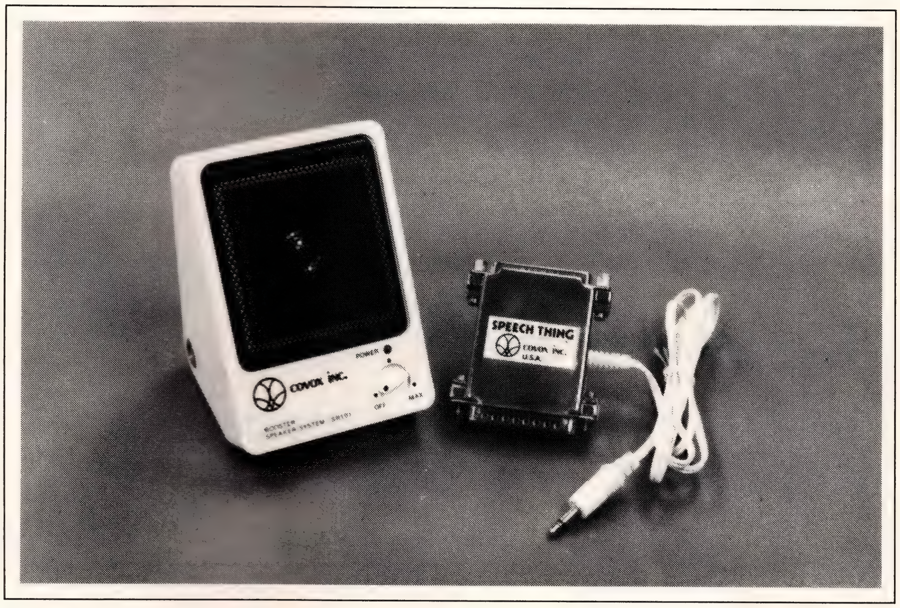
CIRCLE NO 126

COMPONENTS & POWER SUPPLIES

SPEECH GENERATOR

- *Converts digitized speech files into analog speech*
- *Hardware plugs into a DB-25 parallel printer port*

The Speech Thing contains an 8-bit D/A converter that attaches to the DB-25 parallel-printer port on an IBM PC, PC/XT, PC/AT, PS/2, or a compatible computer. It converts digitized speech or sound files into an analog signal for driving a speaker. When attached to the computer, the unit doesn't interfere with the operations of the printer. The package includes a speaker with volume control, demonstration software, and a 2-pg instruction manual. The demonstration software includes a talking calculator, a graphics-based sound editor, and several prerecorded sounds suitable for inclusion in user-written programs—all of which are recorded by the company's Voice Master PC Digitizer software. The package also includes two versions of the SmoothTalker text-to-speech software. Version 2 occupies 80k bytes of memory space in an IBM PC or a compatible computer. Version 3 has language rules that provide improved speech quality, but it requires an IBM PC AT- or PS/2-compatible computer and occupies 160k bytes of memory space. You can call both versions from Basic or C programs. $79.95.



Covox Inc, 675-D Conger St, Eugene, OR 97402. Phone (503) 342-1271. TLX 706017. FAX 503-342-1283.

Circle No 351

MOTION CONTROLLER

- *Controls as many as 4 independent axes*
- *Analog and quadrature feedback inputs for each axis*

The MAC-4 motion controller can control as many as 4 axes independently or in coordination. Three independent μPs control the motion. The unit provides the following kinds of input for each axis: analog, quadrature feedback, home, marker, and limit. The four analog inputs have a voltage range of 0 to 12V dc and all of the digital inputs and outputs are optically isolated. In addition, the unit has 64k bytes of RAM with battery backup and an RS-232C port that communicates with a host computer at 9600 baud. The unit comes with a high-level programming language, MacBasic, that lets you download code developed on an IBM PC/XT or compatible computer. The number of inputs and outputs can be expanded to 64 and 56, respectively, with optional I/O boards. $995 (50).

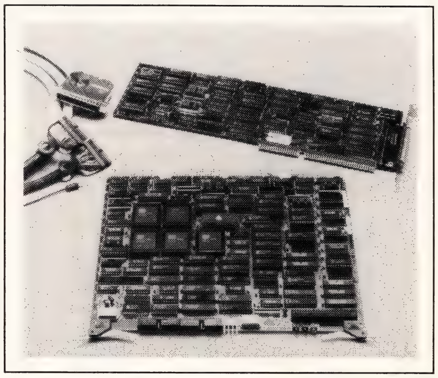
Andtron Motion Control, Box 4170, Muskegon, MI 49444. Phone (616) 739-1407.

Circle No 352

BUS ADAPTER

- *Lets an IBM PC/AT computer operate as a Q Bus master*
- *IBM PC/AT can perform random access to the Q Bus*

The 405 IBM PC/AT-Q22 bus is a bus adapter that permits an IBM PC/AT computer to operate as a bus master or a coprocessor on DEC's Q Bus. It consists of two plug-in circuit cards—one fits in the PC/AT computer and the other fits



inside a Q Bus card cage. The two cards communicate with each other through a shielded cable. The PC/AT can randomly read and write to as much as 4M bytes of memory on the Q Bus. The adapter translates the random accesses into a read or write on the Q Bus. In addition, the Q Bus I/O drivers can access the PC/AT I/O ports and vice versa. Optional daughter boards

that plug into the Q Bus card contain 32k, 128k, or 1M bytes of dual-port RAM, which is accessible to both buses. $2495.

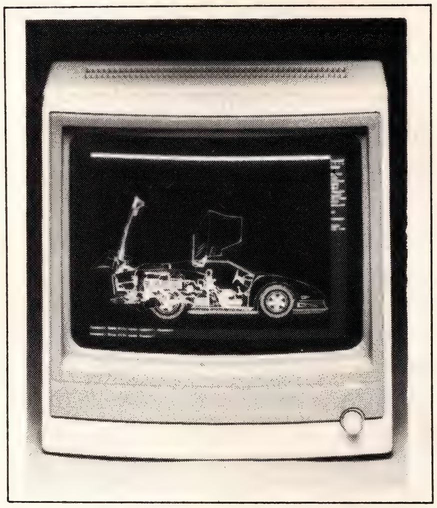
Bit 3 Computer Corp, 8120 Penn Ave S, Minneapolis, MN 55431. Phone (612) 881-6955. TLX 4997016. FAX 612-881-9674.

Circle No 353

VGA MONITOR

- *Has 20-in. display for AutoCAD applications*
- *Graphics card provides 1024 × 768-pixel resolution*

The VGA Solution consists of a VGA monitor and a 16-bit VGA graphics card for AutoCAD applications. It includes the VGA/20, a 20-



in. color monitor that provides an extended VGA resolution of 1024 × 768 pixels. The monitor has an automatic picture-sizing feature, which provides full-screen displays in all VGA modes, including the extended mode. In addition, the product includes the VGA/1024 video adapter board for the IBM PC/XT, PC/AT, and compatible computers. Besides being compatible with the VGA graphics standards, it operates with the CGA, EGA, Hercules, and MDA graphics standards as well. Software drivers for AutoCAD version 2.18 and AutoCAD Release 9 display 16 colors for either 640 × 480- or 1024 × 768-pixel resolutions. The adapter board contains both Hotkey and Zoom Utilities that reside in RAM for hardware zooming, panning, and scrolling. VGA solution, $3240.

Aydin Controls, 414 Commerce Dr, Fort Washington, PA 19034. Phone (800) 366-8889.

Circle No 354

VME 68030 SBC

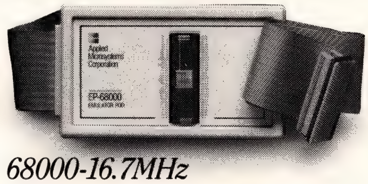
- *Runs at 20 or 25 MHz in a 6U form factor*
- *Contains a 64k-byte cache and 32M bytes of dynamic RAM*

The CVME48 single-board computer runs at 20 or 25 MHz and comes in a 6U form factor for the VME Bus. It features a 68030 µP,

Text continued on pg 196

68020 EMULATION NOW AT 25MHz.

68020-25MHz



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80C186/C188-16MHz

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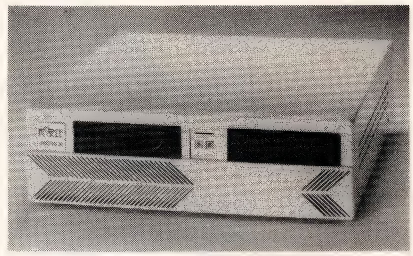
In Europe contact Applied Microsystems Corporation Ltd., Chiltern Court, High Street, Wendover, Aylesbury, Bucks, HP22 6EP, United Kingdom. Telephone 44-(0)-296-625462. FAX 44-(0)-296-623460.
In Japan, contact Applied Microsystems Japan Ltd., Nihon Seimei, Nishi-Gotanda Building, 7-24-5 Nishi-Gotanda, Shinagawa-KU, Tokyo T141, Japan. Telephone 03-493-0770. FAX 03-493-7270.

AMC 247

a 64k-byte zero-wait-state cache memory, as much as 32M bytes of dynamic RAM, an Ethernet interface, four serial ports, a parallel port, a VME Bus master/slave interface, and an option for a 68882 floating-point coprocessor. The board maintains cache coherency by monitoring write cycles for cache hits. If a cache hit occurs during a write cycle, the board invalidates the entry to the cache. The board uses SIMM modules for dynamic RAMs, thus facilitating memory expansion without daughter boards. The VME Bus interface supports dynamic bus sizing and block transfers. It also provides a system controller, a 4-level priority or round-robin bus arbiter, a system fail, a watchdog timer, and a system reset. From $3615 (100).

Cyclone Microsystems, 25 Science Park, New Haven, CT 06511. Phone (203) 786-5536.

Circle No 355



DEVELOPMENT SYSTEM

- *Runs Unix 5.3 operating system in VME Bus environment*
- *Includes automatic VME Bus daisy-chain configuration*

Incorporating a 68030-based CPU card, the System 37U in the Focus 30 range of VME Bus development systems runs the Unix 5.3 operating system. The CPU card includes a floating-point math coprocessor, 4M bytes of dynamic RAM, 32k bytes of battery-backed static RAM, an Ethernet LAN controller, three serial I/O ports, a SCSI bus interface, and a floppy-disk interface that can support Unix 5.3 on this board alone. The CPU board occupies a single slot in the system's 5-slot mother board, which features automatic daisy-chain configuration circuitry, and a 4-level bus arbiter. The automatic daisy-chain configuration allows you to remove or install additional boards without the need to alter any jumper links on the backplane. The development system includes a 90M-byte Winchester disk drive, a 1M-byte, 5¼-in. floppy-disk drive, a 125M-byte tape streamer, and a 300W power supply. It is housed in a fan-cooled chassis that accepts double-height Eurocards and is suitable for use as a desk-top or a 19-in. rack-mount unit. The system meets VDE-0806

Text continued on pg 200

Keep it simple

Great resources are brought to bear on the designs of IC's for your system. When the deadline for your production comes close it's time to conclude the PC-board design and calculate what resistors to use. That's the time you realise you need those complex resistors on that already negative available board space. Don't fret. Write for the free of charge Erisistor PC-program that not only do the calculations but also shows you the price and leadtimes. And in real time!

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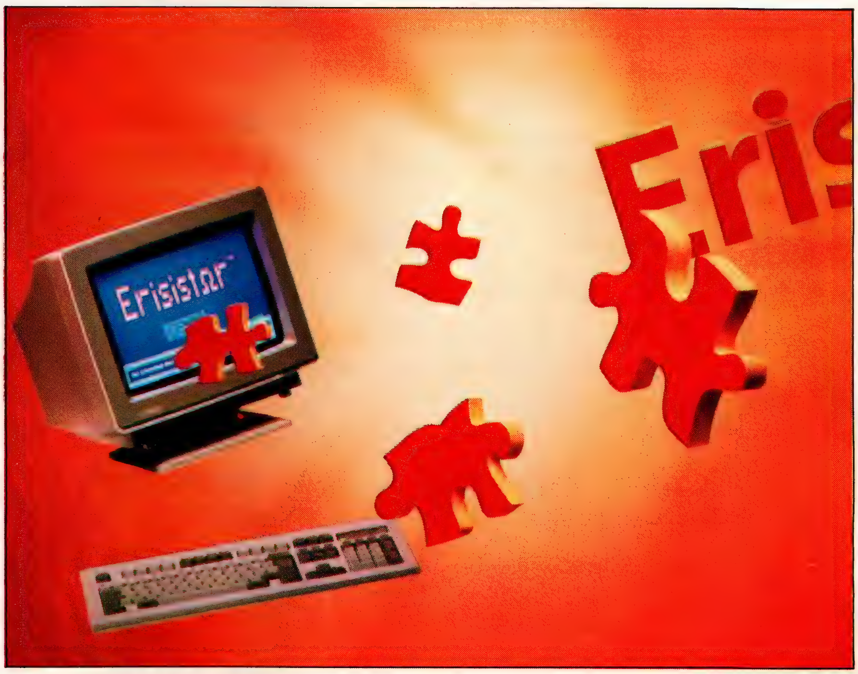

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CIRCLE NO 11

safety requirements and VDE-0871 class B and FCC RFI emission standards. Approximately DM 20,000.

Force Computers GmbH, Daimlerstrasse 9, 8012 Ottobrunn/Munich, West Germany. Phone (089) 600910. TLX 524190. FAX 089-6097793.

Circle No 356

Force Computers Inc, 3165 Winchester Blvd, Campbell, CA 95008. Phone (408) 354-3410. TLX 172465. FAX 408-395-7718.

Circle No 357

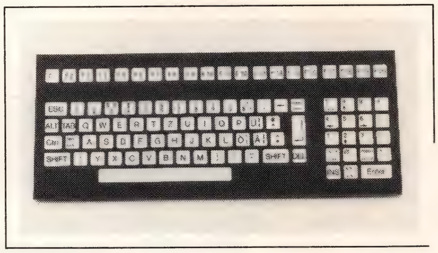
TAPE CONTROLLER

- *Interfaces ½-in. tape drives to the SCSI bus*
- *Includes onboard buffer memory for as much as 1M byte of data*

You can either embed the DIL8844 controller for ½-in. magnetic tape drives in your system or mount it on commercially available ½-in. tape-drive units. The board connects the drive to the SCSI bus and is available in two versions that drive single-ended and differential SCSI buses, respectively. It can operate in either a synchronous or asynchronous data-transfer mode, achieving data transfer rates as high as 4.54M bytes/sec in synchronous mode or 5.55M bytes/sec in asynchronous mode. The controller has an onboard 256k×9-bit parity-checked buffer memory, which you can expand to 1M×9 bits. The single-ended version consumes 700 mA from a 5V supply, and the differential version consumes 900 mA. Single-ended version, £350; differential version, £400 (500).

Digital Interfaces Ltd, C1 The Forelle Centre, Ebblake Industrial Estate, Verwood, Dorset BH21 6BB, UK. Phone (0202) 824277. TLX 8951182. FAX 0202-827655.

Circle No 358



KEYBOARD

- *Suitable for use in harsh industrial environments*
- *Available with RS-232C or parallel interfaces*

Providing resistance to water and a wide range of chemicals, these PC keyboards are suitable for use in harsh industrial environments. They utilize short-stroke switches with a lifetime greater than 1 million operations; they're available as desk-top units, as drawers that fit into 19-in. racks, or as assemblies that you can build into front panels. The desk-top and drawer versions meet the IP 65 requirements for

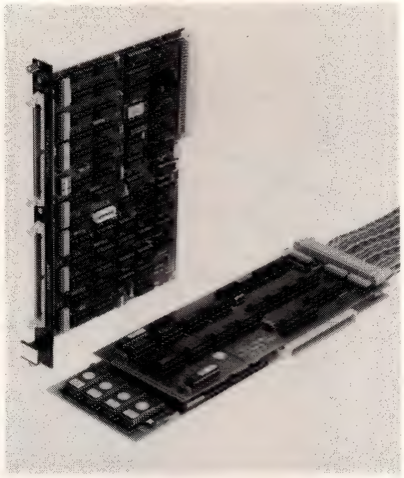
water resistance. The keyboards have a built-in keyboard controller for IBM PC/XT, PC/AT, or compatible computers. They are optionally available with an RS-232C interface or a Centronics-compatible parallel interface. Keyboards with custom electronics are also available. Standard versions, DM 605 to DM 922.

Emtron Electronic Vertriebs GmbH, Rudolf-Diesel-Strasse 14, 6085 Nauheim, West Germany. Phone (06152) 61081. TLX 4191127. FAX 06152-69347.

Circle No 359

INTERFACE KIT

- *Links Macintosh computers to VME or CAMAC systems*
- *Provides transparent memory access*



Using the MacVee interface kit, you can connect a Macintosh II or IIx computer to as many as eight VME or CAMAC systems. The kit comprises an interface card that plugs into one of the computer's Nubus expansion slots, and an interface card for either a VME Bus or CAMAC system. These interface cards are connected by a ribbon cable, which can be as long as 100m, and you can mix VME Bus and CAMAC systems on the same ribbon cable if required. The VME Bus interface card operates as a system controller or data-bus master on the VME Bus and can operate in a multiprocessor VME Bus system. The CAMAC interface card is a dedicated memory-mapped CAMAC system controller. The interface causes the VME Bus or CAMAC system memory to appear in the address space of the Macintosh computer's 68000 family processor, making the interface transparent to the Macintosh's operating system. No special interface drivers are required. VME Bus system, £1380.

Bergoz, Crozet, 01170 Gex, France. Phone 50410089. FAX 50410199.

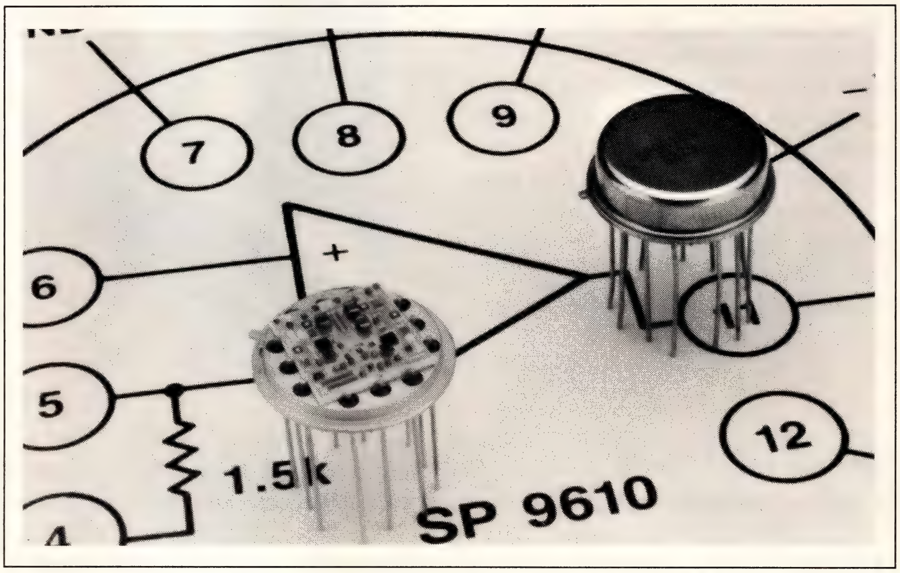
Circle No 360

NEW PRODUCTS

INTEGRATED CIRCUITS

TRANSIMPEDANCE IC

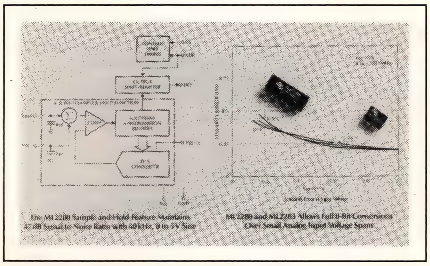
- *Has 100-MHz bandwidth*
- *Settles to 0.1% in 20 nsec*



The SP9610 fast-settling, dc-coupled transimpedance op amp has a 100-MHz unity-gain bandwidth. The device employs a current-feedback architecture to achieve dynamic performance that is essentially independent of closed-loop gain. The −3-dB bandwidth is 100 MHz at a gain of −1, dropping only to 75 MHz at a gain of −20. The SP9610 settles to 0.1% in 20 nsec with an overshoot amplitude of <1%. Operating from ±15V supplies, the SP9610's power dissipation is 420 mW typ and 600 mW max. The output voltage swing is ±10V, and the output current is ±50 mA. The unit is available in commercial and military temperature grades in a TO-8 metal can. Commercial grade, from $50; military grade, from $95 (100).

Sipex Corp, 6 Fortune Dr, Billerica, MA 01821. Phone (508) 663-7811. FAX 508-667-5935. TWX 910-240-5653.

Circle No 365



A/D CONVERTERS

- *Conversion rate is 6 μsec*
- *Include sample-and-hold circuit*

The ML2280 and ML2283 8-bit serial I/O A/D converters feature a 6-μsec conversion rate, including S/H acquisition, that allows digitization of a 0 to 5V sine wave at 40 kHz with a >45-dB S/N ratio. The 1-channel ML2280 and the 4-channel ML2283 feature a $V_{ref}/2$ pin that allows the converters to maintain a 0 to 5V analog input range, using an external 2.5V reference for absolute value conversions. The ADCs include a comparator that is fully differential and auto-zeroed at the start of each conversion to remove any dc offset and full-scale gain error. The converters are available with an unadjusted error of either ±½ LSB or ±1 LSB. In 8-pin DIPs: ML2280BCP, $3.90; ML2280CCP, $2.95; in 14-pin DIPs: ML2283BCP; $4.50, ML2283CCP, $3.20 (100).

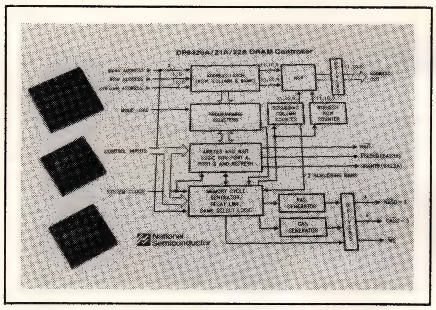
Micro Linear Corp, 2092 Concourse Dr, San Jose, CA 95131. Phone (408) 433-5200.

Circle No 366

DRAM CONTROLLERS

- *Work with 16- and 32-bit μPs*
- *Handle μP speeds to 25 MHz*

The DP8420A, DP8421A, and DP8422A dynamic RAM controllers interface to 16-and 32-bit μPs running at speeds as fast as 25 MHz, regardless of the dynamic RAM access method used. The DP8422A, which has two access ports, can directly address and drive 4M-bit dynamic RAM arrays as large as 64M bytes. The DP8421A is designed for driving 1M-bit dynamic RAMs, and the DP8420A can drive 256k-bit dynamic RAMs. All three chips in-



clude address latches, bank-select logic, wait-state logic, and a delay line and refresh counter. The DP8422A also includes arbitration logic to support shared-memory accessing. For dynamic RAM-based applications employing error detection and correction, the three models allow scrubbing during refresh with on-chip row, column, and bank counters. DP8422A 84-pin plastic leaded-chip carrier, $23.50; DP8420A and DP8421A 68-pin PLCC, $12.50 and $17.97, respectively (100).

National Semiconductor Corp, Box 58090, Santa Clara, CA 95052. Phone (408) 721-5943. TLX 346353.

Circle No 367

M O D - U - F L E X

EURO OR STANDARD PACKAGING SYSTEMS... ALL MADE IN AMERICA!

A unique, versatile and economical system which allows you to choose your board and connector type.

This system has been designed to accept three types of circuit boards and connectors.

Commercial Boards. These off-the-shelf boards are readily available and most commonly used with MIL-C-21097 type edge connectors.

Eurocards. The Mod-U-Flex System is designed to accept Eurocards to DIN 41494 and Euroconnectors to DIN 41612 specifications.

Bud Boards. These standard rectangular-shaped boards, which are commonly used with Bud modular connectors, provide the maximum number of contacts.

Mod-U-Flex allows you the flexibility to design your own system using standard off-the-shelf parts. The system comes in kit form and all components are fabricated to exacting standards. And, all are in stock for immediate delivery.

And you thought you knew Bud.

Bud East, Inc.
4605 East 355th Street
P.O. Box 431
Willoughby, Ohio 44094
(216)946-3200
TWX 810-427-2604

Bud West, Inc.
7733 West Olive Avenue
P.O. Box 1029
Peoria, Arizona 85345-0350
(602) 979-0300
TWX 910-951-4217

CIRCLE NO 129

CIRCLE NO 133

SAMPLING ADC

- *Provides 12-bit resolution*
- *Has a dc to 10-MHz sampling rate*

Suited to high-performance signal-processing applications, the ADC603 hybrid A/D converter (ADC) offers a resolution of 12 bits. At a 10-MHz sampling rate, the ADC features a typical differential nonlinearity of 0.4 LSB and a maximum nonlinearity of 1 LSB. Other specifications include a signal-to-noise ratio of 68.2 dB at 5 MHz, an input analog bandwidth of 70 MHz, and 2-tone distortion products of −77.7 dB. The ADC603 contains a sample/hold circuit, a 2-step subranging ADC, a voltage reference, and circuitry for timing and error correction. The ADC603 is available in both commercial and military temperature ranges and is packaged in a 46-pin, hermetic ceramic/metal DIP. $950 (500).

Burr-Brown Corp, Box 11400, Tucson, AZ 85734. Phone (602) 746-1111.

Circle No 368

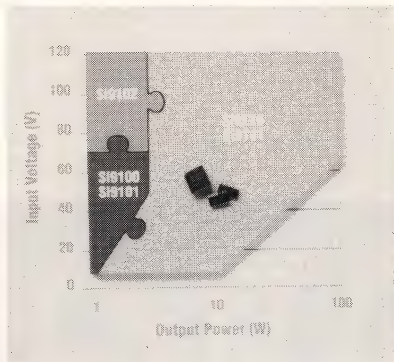
MODEM CHIP SET

- *Has a 2400-bps transfer rate*
- *Features advanced error correction*

The 89C024XE 2400-bps modem chip set conforms to the Microcom Networking Protocol Class-5 specifications for advanced error correction and data compression. The chip set provides data-compression transfer rates to 4800 bps and supports all modem functions, including the industry-standard AT command set. The 89C024XE consists of a 16-bit ASIC microcontroller and an analog, front-end interface. The microcontroller handles digital signal processing and modem control functions. The analog device provides 2- and 4-wire telephone interfaces, D/A conversion, and the complex filtering a modem normally requires. The 89C024XE conforms to Bell 103 and 212A, and CCITT V.21 and V.22 standards. $40 (1000).

Intel Corp, Box 58065, Santa Clara, CA 95052. Phone (800) 548-4725.

Circle No 369



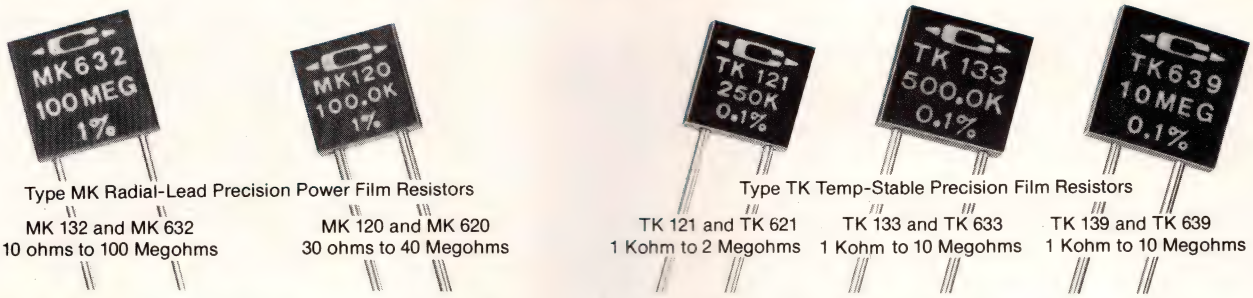
SWITCH-MODE ICs

- *Available in surface-mount packages*
- *Feature 80% efficiency to 3W*

The Si9100, Si9101, and Si9102 switch-mode regulators are now available in 20-pin PLCCs, and the Si9110 and Si9111 switch-mode controllers are available in 14-pin narrow-body SO (small-outline) packages. The regulator chips include high-voltage startup circuitry, an oscillator, an error amplifier, a voltage reference, and an onboard high-voltage MOSFET. They feature >80% power conversion to 3W. The controllers allow the use of an external power MOSFET, thus extending the power range to 100W. With a low-supply current of less than 1 mA, these switch-mode ICs meet the power requirements of

Text continued on pg 208

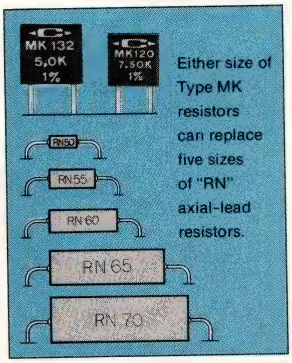
Radial-Lead Precision Film Resistors from Caddock combine high values and tight tolerances with a choice of two high-power densities or three low TCs.



Type MK Radial-Lead Precision Power Film Resistors utilize Caddock's Micronox® resistance films to achieve high power density and an extended range of resistance values:

Available in two rectangular radial-lead packages that include values as high as 100 Megohms, these high-density film resistors permit electronic circuit designers to optimize packaging and PC board layouts with resistors that meet all these specifications:

	MK 120	MK 620	MK 132	MK 632
• Resistance Range	30 ohms to 2 Megohms	2.1 Megohms to 40 Megohms	10 ohms to 5 Megohms	5.1 Megohms to 100 Megohms
• Resistance Tolerance	±1.0% is standard, to ±0.1% on special order, depending on value and model.			
• Wattage	0.5 Watt	——	0.75 Watt	——
• Voltage	200 V	200 V	400 V	400 V
• Temperature Coefficient	50 PPM/°C	80 PPM/°C	50 PPM/°C	80 PPM/°C
	Temp Range: −15°C to +105°C, ref. +25°C.			
• Package Size	.250" square, .100" thick		.300" square, .100" thick	



These full-size photos comparing the Type MK resistors to "RN" style axial-lead resistors show that the largest Type MK, which is rated at 3/4 watt, requires less board space than the 1/20 watt "RN 50".

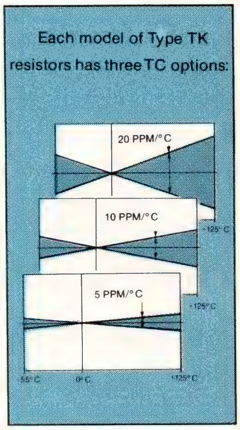
And within their voltage ratings, both sizes of Type MK resistors can replace five sizes of "RN" resistors, including the 1/2 watt "RN 70" which requires 10 times the board space of the MK 132!

This combination of higher power rating and smaller size can also lower procurement costs by replacing many sizes of axial-lead resistors with Type MK resistors that have a 'standard' size and mounting dimensions.

Type TK Temp-Stable Precision Film Resistors with Caddock's Tetrinox® resistance films combine a choice of TCs of 5, 10 or 20 PPM/°C, a wide resistance range and tight tolerances.

Type TK Temp-Stable Precision Film Resistors provide a combination of performance advantages that are unique in a miniature resistive component:

- **Three Standard Temperature Coefficients:** 5 PPM/°C, 10 PPM/°C or 20 PPM/°C over the temperature range from −55°C to +125°C. (+105°C max. for values above 500 Kohms or 1.5 Megohms, depending upon model.)
- **Resistance Range:** 1 Kohm to 10 Megohms.
- **Precision Tolerances:** ±1.0% is standard, and tolerances as close as ±0.05% are available on special order.
- **Load Life Stability:** 0.05% maximum ΔR after 2000 hours at full power at +125°C. (0.2% max. for values above 500 Kohms or 1.5 Megohms, depending upon model.)
- **Two Power Ratings:** .2 watt and .3 watt.



The Model TK 121, TK 133 and TK 139 precision film resistors have demonstrated performance which meets the requirements of Mil-R-55182/9 for thermal shock, moisture resistance, shock and vibration, dielectric withstanding voltage and low temperature operation.

Caddock's high-thru-put manufacturing techniques combined with our advanced Tetrinox® resistance film technology provide this cost-effective way to match the needs of temperature stable circuitry. For price and delivery information on both production and evaluation quantities, contact Caddock's main offices in Riverside, California.

Discover how easily these problem-solving resistors can improve the performance and reliability of your equipment, too. For your copy of the latest edition of the Caddock 28 page General Catalog, and specific technical data on any of the more than 200 models of the 19 standard types of Caddock High Performance Film Resistors and Precision Resistor Networks, just call or write to –

Caddock Electronics, Inc., 1717 Chicago Avenue, Riverside, California 92507 • Phone (714) 788-1700 • TWX: 910-332-6108

CADDOCK

HIGH PERFORMANCE FILM RESISTORS

CIRCLE NO 130

ISDN terminals. $4.06 to $6.68 (100).

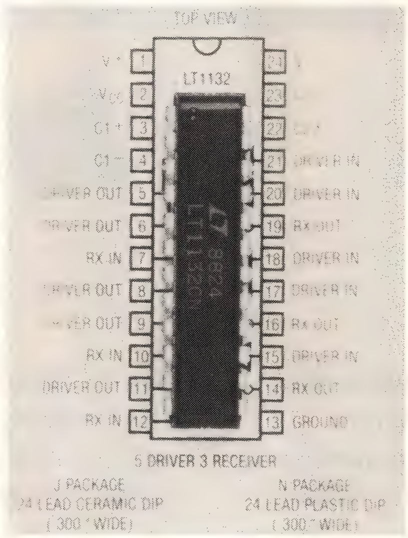
Siliconix Inc, 2201 Laurelwood Rd, Santa Clara, CA 95054. Phone (408) 988-8000.

Circle No 370

RS-232C TRANSCEIVERS

- *Operate from a 5V supply*
- *Two options are available*

The LT1132 and LT1133 transceivers simplify system design and power supply requirements for personal computers and personal-computer peripheral serial communication. The LT1132 is a 5-driver, 3-receiver RS-232C transceiver for use in personal-computer-compatible peripherals, such as modems, and the LT1133 is a 3-driver, 5-receiver RS-232C transceiver for use in personal computers. These combinations of drivers and receivers allow the use of only one transceiver IC per RS-232C communications port. The transceivers, which are capable of data rates >64k baud, require only a 5V supply and a 1-μF charge-pump capacitor for operation. The RS-232C outputs of the ICs can withstand ±30V without forcing current back into the power supply. The transceivers are available in 24-pin plastic or ceramic DIPs and 24-pin plastic SOIC packages. Plastic DIPs, $5 (100).



Linear Technology Corp, 1630 McCarthy Blvd, Milpitas, CA 95035. Phone (800) 637-5545; in CA, (408) 432-1900. FAX 408-434-0507.

Circle No 371

WIDE-BAND OP AMP

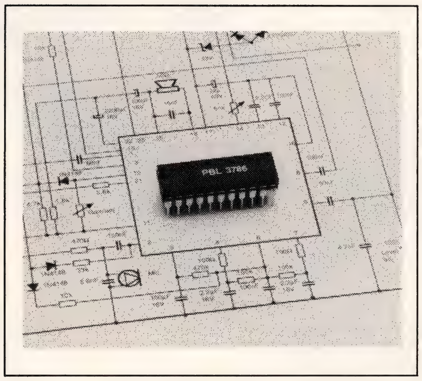
- *Provides a 165-MHz bandwidth*
- *Offers a 15-nsec settling time*

Based on a current-feedback architecture, the THC4231 op amp features a −3-dB bandwidth of 165 MHz and a settling time of 15 nsec to 0.05%. The op amp has a 1-mV input offset voltage and a drift of 10 μV/°C. The THC4231 comes in a 12-lead, TO-8-style metal can and is manufactured in facilities that are certified to MIL-STD-1772. MIL-

STD-883 screening is available. The THC4231-X1B is specified over an ambient temperature range of −25 to 85°C; the THC4231-X1V is specified over the range of −55 to 125°C. B-grade, $52; V-grade, $127 (1000).

TRW LSI Products Inc, Box 2472, La Jolla, CA 92038. Phone (619) 457-1000.

Circle No 372

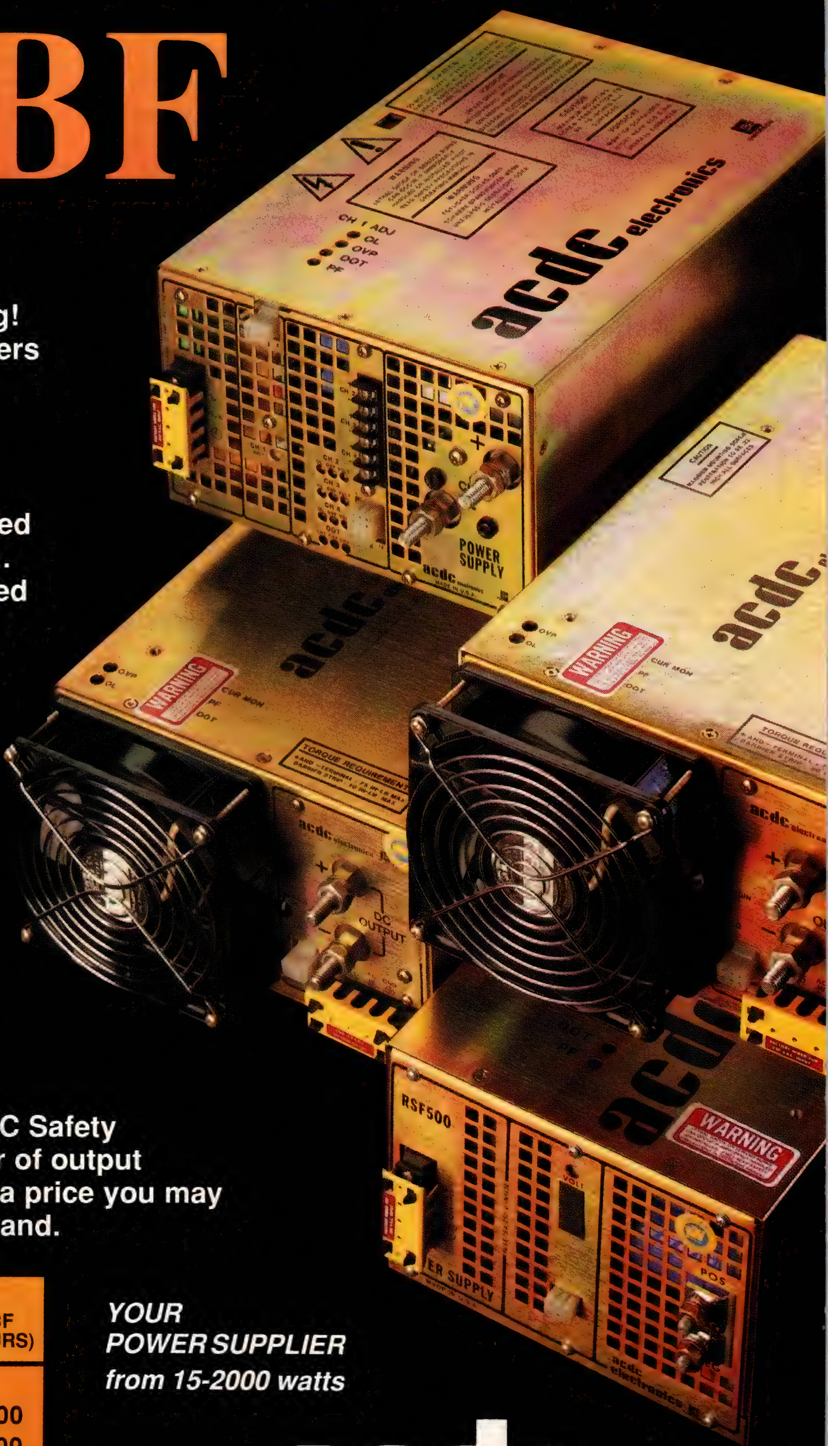


PHONE IC

- *Includes speakerphone and tone-ringer functions*
- *Receives power from telephone lines without using inductors*

The bipolar PBL 3786 circuit incorporates a voice-switched speakerphone, a loudspeaker amplifier, and an adjustable tone ringer on a single IC. You can power the device directly from the telephone line without using inductors. The loudspeaker volume automatically decreases under low line-current conditions, allowing the device to operate at line currents as low as 10 mA from a 3.5V supply. The device's microphone amplifier incorporates a background-noise detector that allows the speakerphone functions to operate in noisy environments. The on-chip tone-ringer eliminates the need for a separate transducer by sharing the ICs amplifier and loudspeaker with the speakerphone circuit. You can adjust the tone-ringer's frequencies and frequency switching rate with external capacitors. The PBL3786 is packaged in a 22-pin plastic DIP.

500,000hrs. MTBF



That's acdc. Power Supplies built to keep working, and working, and working! Specifically, our 500 to 1500 watt switchers have MTBF numbers that literally just won't quit.

INDUSTRY LEADERSHIP

Reliability is designed in first, and verified during the development of each product. Every unit is manufactured with controlled processes, thoroughly computer tested and burned-in at full load (40°C with 60 second AC cycling for up to 48 hrs.), acdc builds supplies like nobody else.

The result is this...exceptionally high MTBF performance demonstrated in the field, setting the new industry standard for reliability.

GREAT FEATURES... GREAT PRICE!!!

Of course our supplies meet UL, CSA, IEC Safety Specs and can be ordered in any number of output configurations. All this performance for a price you may already be paying for a not-so-reliable brand.

OBSERVED MTBF

MODELS	POWER	UNITS	MTBF (HOURS)
SINGLE'S			
RSF501	500W	9,000	877,000
JF751	750W	8,000	448,000
JF101	1000W	11,000	403,000
JF151	1500W	3,000	400,000
MULTI'S			
RSF504	500W	8,000	346,000
REV804	800W	10,000	365,000

acdc has maintained a complete database of shipments and returns since 1985. Observed MTBF statistics are calculated per MIL-STD-781.

YOUR POWER SUPPLIER from 15-2000 watts

acdc electronics

401 JONES ROAD, OCEANSIDE, CA 92054
TEL: 619-439-4200 FAX:619-439-4243

CIRCLE NO 131

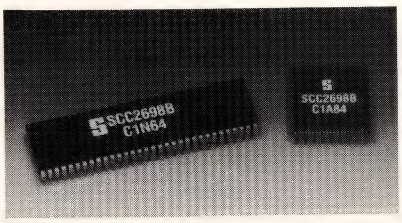
$3.85 (10,000). Delivery, stock to 16 weeks.

Ericsson Components AB, Microelectronics Div, Isafjordsgatan 16, 16481 Kista-Stockholm, Sweden. Phone (08) 7574354. TLX 8125008. FAX 08-7526034.

Circle No 373

Ericsson Components Inc, 403 International Parkway, Richardson, TX 75081. Phone (214) 480-8300. FAX 214-680-1059.

Circle No 374



CMOS OCTAL UART

- *Has eight receive/transmit channels*
- *Operates with 20 mA of current*

The SCC2698B CMOS UART (Universal Asynchronous Receiver/Transmitter) features a current operation of 20 mA. In addition to its eight independent, full-duplex receive/transmit channels, the UART contains four general-purpose, 16-bit counter/timers; a baud-rate generator (BRG); a crystal oscillator circuit; and five I/O pins per channel. You can program the I/O pins to serve several functions: modem control signals, clock inputs and outputs, DMA service requests, and interrupt requests. The SCC2698B supports all asynchronous data formats via programmable character length, stop bits, and parity. The internal BRG provides 18 frequently used communication rates from 50 to 38.4k baud. 64-pin DIP, $26.50; 84-pin PLCC, $27.75 (100).

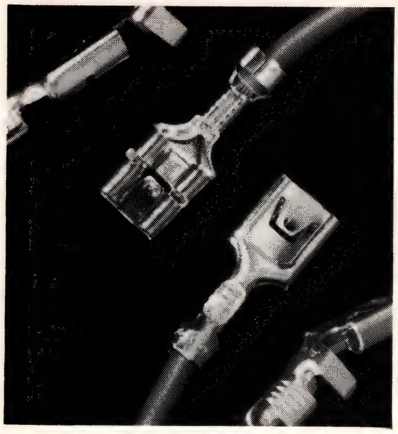
Signetics Co, Box 3409, Sunnyvale, CA 94088. Phone (408) 991-2000.

Circle No 375

CIRCLE NO 19

CIRCLE NO 20

COMPONENTS & POWER SUPPLIES



RECEPTACLES

- *Offer low insertion force*
- *Accommodate wide range of wire sizes*

These receptacles feature a 2-stage roll configuration and a cantilever floor design. These features cause the mating tab to depress the locking dimple and minimize insertion force when it would normally be at its peak without violating UL 310 requirements for mininum withdrawal force. Series 250 receptacles have a maximum insertion force of 9 lbs and accept wire ranges of #18 to 14 AWG and #14 to 10 AWG in straight versions, and #18 to 12 AWG in flag configurations. Series 187 units accept a wire range of #20 to 16 AWG in straight and flag versions, and feature a 7-lb insertion force. You can terminate the receptacles, using either bench or high-speed automatic equipment. $0.009 to $0.015 (1000).

AMP Inc, Box 3608, Harrisburg, PA 17105. Phone (717) 564-0100. FAX 717-561-6179.

Circle No 380

CONNECTORS

- *Designed for automatic testing applications*
- *All models are UL recognized*

Designed for burn-in and automatic testing applications involving temperatures of 150°C, these edge-board connectors are available with

FLASH!

BUSSMANN IS OVER-VOLTAGE PROTECTION, TOO.

You think of Bussmann as the major source of over-current protection devices. But that's only half the story. Because Bussmann is now the source for over-*voltage* protection, too. We've just acquired Beswick of England, a major producer of gas-discharge tube, voltage-surge arresters. ■ Advanced gas-discharge tubes have unique capabilities for suppressing transient (and under certain conditions, even continuous) abnormal voltages induced in electronic circuits and systems by lightning or man-made conditions. In a given volume, they offer the highest energy-handling capability of all over-voltage shunt devices. Also, high-speed of operation and rugged reliability—withstanding thousands of transients without damage or change in characteristic. ■ These advantages make the gas discharge tube the preferred device for protection of electronic solid-state equipment: telecommunications, computers, cable television and alarm systems; instrumentation; process control; military electronics and most importantly, personnel. And it can be fitted to operate fail-safe, with a thermal switch, which short circuits the device under a continuous high-level fault. ■ For complete information contact your Buss-Plus Distributor or Bussmann Sales Engineer, your source for both over-voltage and over-current protection. Bussmann Division, Cooper Industries, Box 14460, St. Louis, MO 63178, (314) 394-BUSS.

COOPER INDUSTRIES

BUSSMANN

CIRCLE NO 132

To give thermal cracking the cold shoulder, get acquainted with KEMET's new crack-resistant ceramic chips.

Years In The Making: It took nearly two years of dedication — modifying basic materials using new analysis tools, adapting different test and process techniques — but we developed a ceramic dielectric that won't wilt under thermal stress.

Dramatic Success: In stringent board tests at 260 °C with no preheating, our new 1206-size chip offered dramatically improved survival rates after 300,000 tries. We compared our new chip with three other suppliers' chips under these same conditions, and our chip was the best.

Send for your free package of test data today, or call KEMET for a by-phone consultation.

Making It Easy: Give our new chip a try in your application. As a special offer, for orders placed between January 1, 1989 and March 31, 1989, we will give you a free reel of chips for every 10 reels of a 1206, 0.1 μF, X7R, $\pm$10% or $\pm$20% chip you buy from us.

Orders placed must be shipped to you within 90 days. A copy of this advertisement must accompany your order. *P.O. Box 5928 Greenville, SC 29606 803/963-6300*

KEMET®
Electronics Corporation

CIRCLE NO 135

COMPONENTS & POWER SUPPLIES

center-to-center contact spacings of 0.1, 0.125, and 0.156 in. for Series EB4, Series EB6, and Series EB7/8, respectively. Available in sizes ranging from 6 to 65 contacts/side, the connectors come in right-angle, hard-wire, card-extender, and wire-wrap versions. The units feature a molded fiberglass-reinforced phenolic body and gold-plated copper-alloy contacts. All models are recognized under the UL component program and are listed under File E65524. Series EB6 unit with 25 positions, 30-μin. gold plating on the contacts, and hard-wire terminations, $9.21 (100).

Dale Electronics Inc, 1122 23rd St, Columbus, NE 68601. Phone (605) 665-9301.

Circle No 381

CONTROLLER

- *Accurate to within 0.25%*
- *Accepts a variety of input signals*

Housed in a ⅛-DIN panel mounting package, the 4025 Series setpoint indicating controller employs solid-state circuitry to achieve an accuracy within 0.1 to 0.25%. Providing On/Off control or alarm-action capability, the meter will accept inputs directly from voltage or current transmitters, as well as thermocouple or RTD sensors. Features include a high-resolution 3¾-digit LED display, adjustable deadband and time delay, simple front-panel controls, and dual outputs for alarm or control high/low, high/high, or low/low. $249.

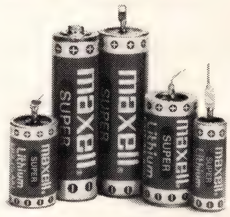
Extech Instruments Corp, 150 Bear Hill Rd, Waltham, MA 02154. Phone (617) 890-7440.

Circle No 382

Text continued on pg 218

POWER PLUS SAFETY.

The Maxell Super Lithium Battery.* Good for a decade, these lithium thionyl chloride batteries are hermetically sealed for super safety plus long shelf and service life. And at 3.6 volts, they supply the high energy density you're looking for.



Specify Maxell Super Lithium Batteries for critical applications where a safe battery is imperative.

Specify Maxell Super Lithium Batteries for quality and a name you can trust. When you need power and you need it safe, look for Maxell.

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22-08 Route 208
Fair Lawn, NJ 07410

*Recognized under the Component Program of Underwriters Laboratories.

SUPER POWER!

High reliability ELCOM® brushless DC servo motors are ideally suited to continuous process applications as well as demanding motion control functions in automated equipment. Optional, integrally mounted optical encoders facilitate use with latest digital control systems. Now available in 3 frame sizes and multiple lengths up to 50mm square x 100.4mm long. Continuous duty outputs to 47 oz.-in. at 7,200 rpm (1/3 hp).

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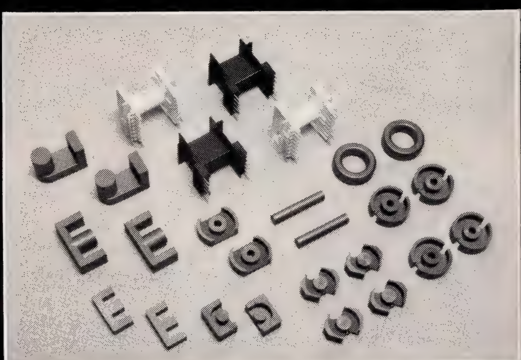
CIRCLE NO 25

FERRITE CORES IN STOCK!

Broad range. High Quality. Competitively Priced.



- Ring Cores
- E Cores
- Screw Cores
- U Cores
- RM Cores
- EP Cores
- Pot Cores
- Touch Tones
- Rods & Tubes
- Chokes
- Beads

An international producer for more than 35 years!

The Neosid warehousing operation enables shipments of a wide range of standard ferrite products from stock. For engineering assistance or additional information, call Neosid today.

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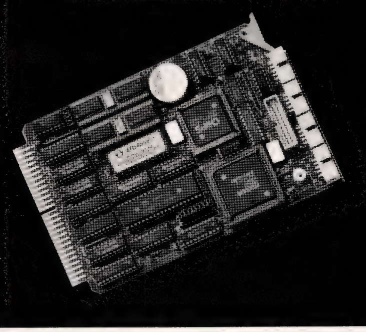
201-389-4411; FAX: 201-389-8128; Telex: 4974568 NEOSID.

TINY Industrial PC



Put PC power onto a 4.5" x 7" card. Octagon's 8500 STD-XT™ CPU card answers the need for PC compatibility in small, embedded control systems:

- COM1 and COM2 serial ports
- LPT1 printer port
- Battery–backed calendar clock
- 128K static RAM
- 128K RAM/ROM disk
- 7.15 MHz. V20 CPU
- Keypad port
- Phoenix™ BIOS
- IBM PC™ compatible chipset
- Watchdog timer
- Extended temp. range–CMOS

STD Bus – PC Connection

Use the 8500 as a stand–alone card or as a gateway to more than 1,000 industrial peripheral cards available on the STD Bus. Write your application in any PC language and run it on the STD Bus. Boots from on–card ROM disk. Add up to 16 MBytes of RAM/ROM disk for reliable operation in the industrial environment. MS–DOS™ ROM, floppy hard disk and video optional.

FROM $645

FREE 1989 CATALOG

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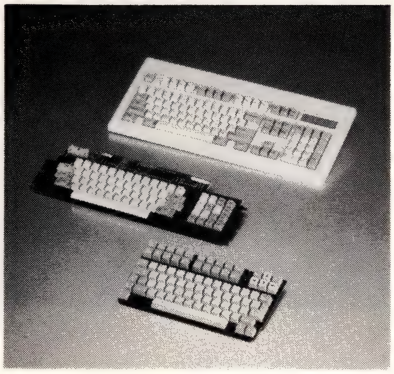
Westmister, CO 80030
FAX: (303)426-8126
(303)426-8540

MEMBER STDMG STD MANUFACTURER'S GROUP

CIRCLE NO 27



KEYBOARDS

- *Available with either mechanical or membrane switches*
- *Compatible with IBM PC/XT, PC/AT, and PS/2*

RT-101, RT-101+ and RT-102 keyboards are all compatible with the IBM PC/XT, PC/AT, and PS/2. They offer a choice of mechanical or membrane-type keyswitches. The mechanical keyswitch versions feature a 100M-cycle lifetime. Membrane versions are available with either linear or tactile key feels. The linear-feel switch features a spring-return mechanism instead of the traditional rubber boot. The units feature a streamlined enclosure. $37.50 (50).

NMB Technologies Inc, 9730 Independence Ave, Chatsworth, CA 91311. Phone (818) 341-3355. FAX 818-341-8207. TWX 910-494-1232.

Circle No 383

POWER SUPPLY

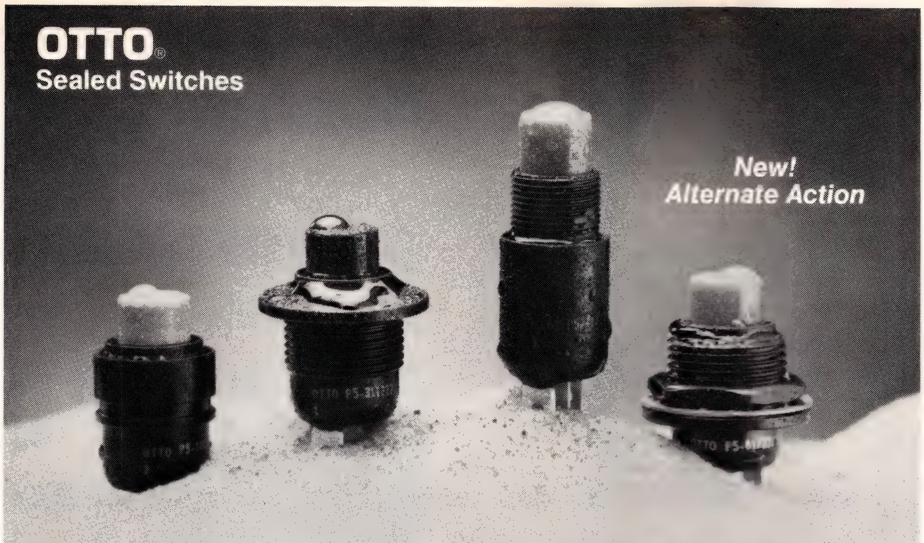
- *Has a 24V dc output*
- *Output set to within ±1%*

Model CM1.24.240 modular encapsulated power supply provides a 24V/400-mA output—enough power for 12 to 15 4- to 20-mA loops. The supply regulation equals 0.05%, and maximum noise and ripple are below 1 mV rms. The output voltage is factory set to within ±1% of 24V.

Fold-back current limiting is provided for continuous short-circuit protection. The units will operate at 50°C without derating. The 4×2.7×1.4-in. case features four molded-in threaded inserts and four through-holes that provide two methods of fastening the supply to a chassis or NEMA-box back plate. The barrier-strip terminals feature a stepped-down design to provide some protection. From $115.

Calex Mfg Co Inc, 3355 Vincent Rd, Pleasant Hill, CA 94523. Phone (415) 932-3911. FAX 415-932-6017.

Circle No 384



Dry Desert to Wet World

Survival! That's what you can expect from OTTO precision snap-action pushbutton switches. Sealed to survive the rigors of industrial, commercial and military applications, these switches are available in momentary and alternate (push-on, push-off) action, miniature and subminiature sizes, choice of front panel appearance and button colors.

Sealed against dirt and water. Electrical ratings from computer level to 10 Amperes. Contact resistance < .025 ohms.

OTTO®
CONTROLS Division, **OTTO** ENGINEERING, INC.

2 East Main Street • Carpentersville, Illinois 60110 • Phone: 312/428-7171 • FAX 312/428-1956 • TELEX: 72-2426

CIRCLE NO 30

NEW FROM ERICOMP

The Minimus™ general purpose single-board computer is ideal for a realtime multitasking control environment. Data acquisition is possible through 8 analog input channels and 24 digital inputs. Control signals are available via 4 analog outputs and 24 digital outputs. Analog channel voltage ranges can be user configured quickly and easily.

The Minimus is based around Intel's 16-bit CMOS 80C188 microprocessor, which includes two DMA channels, three timers, an interrupt controller and a wait state generator.

The Minimus is capable of directly communicating with an IBM* PC via its 62 pin edge connector.

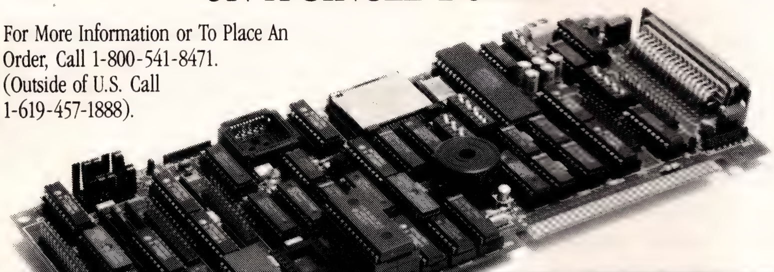
■ Low power (200 mA TYP) ■ 8 channel, 10 Bit A/D ■ 4 channel, 8 bit D/A ■ 48 general purpose digital I/Os ■ 3 programmable timers ■ 80C188 Microprocessor (16 bit) ■ Up to 64K x 8 RAM (32K x 8 non-volatile) ■ Up to 128K x 8 PROM ■ Single supply (9 to 12V) ■ RS232 Interface ■ Real time clock/calendar ■ IBM PC compatible interface for coprocessing applications ■ Optional software driver package available

ERICOMP INC

ERICOMP, INC.
10055 Barnes
Canyon Rd.,
San Diego, CA
92121

DATA ACQUISITION AND DATA PROCESSING ON A SINGLE BOARD

For More Information or To Place An Order, Call 1-800-541-8471. (Outside of U.S. Call 1-619-457-1888).

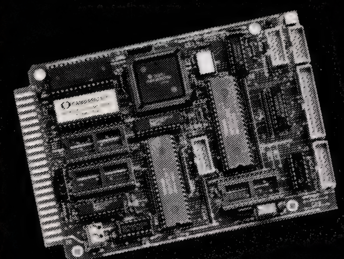


MINIMUS™ General Purpose Single Board Computer **$495.00** Introductory Price Offer

* IBM is a registered trademark of International Business Machines
**Price subject to change without notice.

CIRCLE NO 31

INTELLIGENT Acquisition and Control



Octagon's SBS-250 is an intelligent data acquisition and process control system on a single card. This low–cost system integrates software, hardware and a development system. Just bolt it down—no card cage—no expensive power supplies:

- Autorun on power-up
- 4–Channel 12–bit A/D
- Expandable
- 32 digital I/O lines
- Battery–backed RAM
- EPROM programmer
- 2 serial ports
- Realtime clock
- High speed counter
- Opto module port
- Extended temp. range–CMOS

Industrial Basic Included

Multitasking CAMBASIC II™ language supports all hardware including interrupts, bit manipulation, communications, data acquisition and more:

- Talk to modems and to PCs up to 5,000 feet away
- Program it in the field
- More than 1,200 commands per second
- Write and debug your program then type "save" to store it in EPROM

FROM $395

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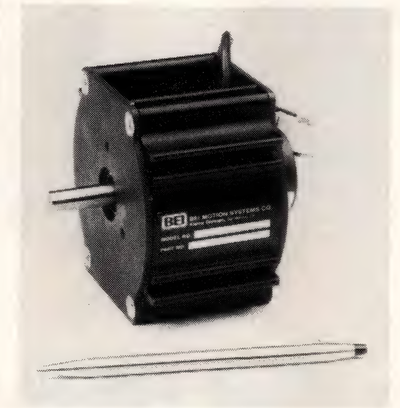
OCTAGON SYSTEMS CORPORATION
6510 W. 91st Avenue
Westmister, CO 80030
FAX: (303)426-8126
(303)426-8540

CIRCLE NO 32



DC MOTORS

- *Immune to thermal runaway problems*
- *Available with encoders*

Series D1138 brushless dc motors feature molded samarium-cobalt magnets that make the motors immune to demagnetization and thermal runaway problems. The 36-slot laminated stator reduces cogging to virtually imperceptible levels. Mechanical time constants range as low as 7 msec. The motors have a stall torque of 1500 oz-in., linear-speed torque characteristics, and continuous stall torques ranging to 120 oz-in. The motors have a maximum rotor speed of 8000 rpm and will accept input drives ranging to 300V dc. Options include optical encoders, hollow shafts, and complementary commutation electronics. From $350.

BEI Motion Systems Co, Box 1626, San Marcos, CA 92069. Phone (619) 744-5671. TWX 910-322-1168.

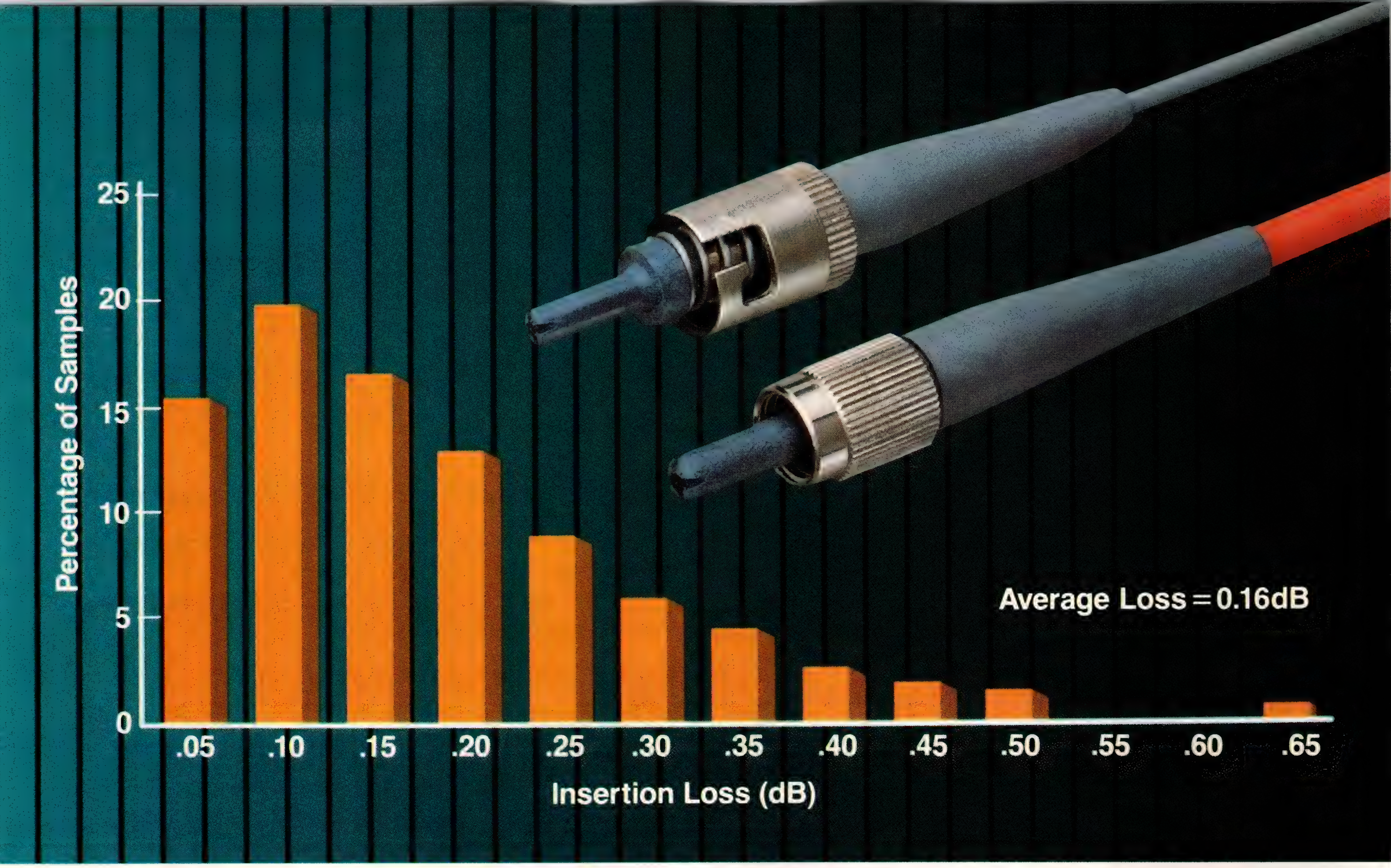
Circle No 385

POWER SUPPLY

- *10 minutes of full-load battery operation*
- *Remote alarm contacts available*

Designed for military applications, the Galaxy 5000 5-kVA uninterruptible power supply fits into a standard 19-in. rack. A complementary battery pack provides as much as 10 minutes of operation at full load. The unit can operate with inputs

Text continued on pg 224

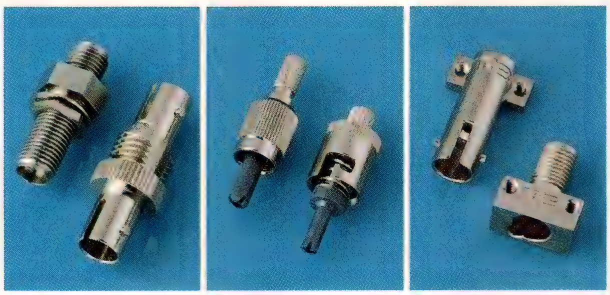


THE PRE-CAP™ CONNECTOR SYSTEM—A FIBER OPTIC CONNECTOR TECHNOLOGY THAT ANSWERS YOUR NEEDS FOR HIGH PERFORMANCE AND HIGH YIELD.

Now you can have consistent performance, high yield, and high reliability when you use our precision capillary PRE-CAP™ series fiber optic connector system. This new-technology system for glass optical fibers includes a line of the most common fiber optic connector designs–SMA and ST* types.

PRE-CAP™ series connectors combine a durable composite polymer alloy with the precision tolerance of a glass capillary to provide an extremely cost-effective connection system. PRE-CAP™ connectors provide superior alignment while matching the thermal stability of the glass fiber.

And, that's not all. With the PRE-CAP™ connector series, you get a simplified crimp and polish termination in a reduced amount of polishing time. The unique glass capillary design virtually eliminates the risk of over-polishing of the glass fiber because the fiber and capillary are uniformly polished as one. This uniform polishing means faster installation without sacrificing the quality of the connection.



Passive Couplers *Connectors* *Active Couplers*

Both the SMA and ST types are highly suitable for manual or automated polishing and are adaptable on all styles of optical fiber cables. The SMA type is compatible with the 905 connector design, while the ST type features a spring-loaded bayonet lock.

In addition to connectors, the PRE-CAP™ connector series includes active and passive couplers, easy-to-use termination tooling, plus standard and custom cable assemblies. For more information or a demonstration of what PRE-CAP™ connector technology can do for you, call or write Thomas & Betts Corporation, Electronics Division, 1001 Frontier Road, Bridgewater, NJ 08807, (201) 685-1600.

To get literature immediately call:

1-800-344-4744

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MICE®

FORETELLS YOUR DEVELOPMENT NEEDS...

MICROTEK offers a complete line of MICE (Micro-In-Circuit-Emulator) for most popular 8, 16 and 32-bit microprocessors. These series of MICE are capable of debugging high speed targets without accumulating wait state, e.g. 25 MHz for 68020, 16 MHz for 68000/80C186. Protected Mode in 80386, coprocessor emulation in 16/32 bit series and bus/execution breakpoints in all series, are few examples of MICE powerful emulation features designed to meet advanced development needs.

All MICE series could work well with IBM PC/XT/AT*, IBM PS/2*, VAX*, μVAX*, Apollo*, Sun* and NEC* 98 series. Cross assembler/compiler, symbolic debugger and high level language debugger are also available to offer optimized software tool supports to an advanced development environment.

MICE SERIES AVAILABLE MODELS

μC	8048 Family, 8052 Family, Z8, ZS8, 68HC11, 80515/535, V25
8-BIT	8085, 6809/E, Z80, NSC800, 6502F, 64180
16-BIT	80C86/88, 80C186/188, 80286, 68000/010, 68008, V20/30
32-BIT	80386, 68020 (25 MHZ)

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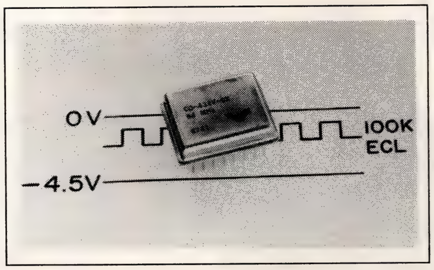
of 120, 208, 220, or 240V ac—all at 50 or 60 Hz. Two pc boards provide all the necessary signal-processing and control signals. System diagnostics are displayed on the front panel along with audible alarms. Alarm contacts are available for remote monitoring applications. The UPS is available in a shock-mounted case and meets the requirements of MIL-STD-810C, as well as the EMP requirements of MIL-STD-462. $6495. Delivery, eight weeks ARO.

Nova Electric Inc, 263 Hillside Ave, Nutley, NJ 07110. Phone (201) 661-3434.

Circle No 386



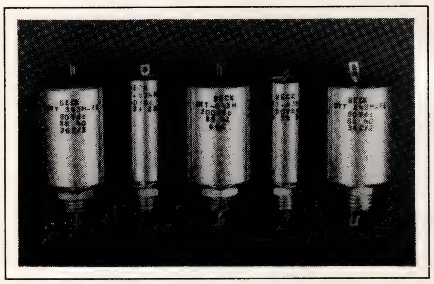
CLOCK OSCILLATORS

- *Frequencies range to 400 MHz*
- *Feature ECL-compatible outputs*

CO-450 Series hybrid DIP clock oscillators are available with outputs ranging from 5 to 400 MHz. They provide complementary 100K ECL outputs and operate from supply voltages of −4.5 or −5.2V dc. Standard stability is 25 ppm over a 0 to 70°C range. Units are available with ±5-ppm temperature stability and wider operating ranges as an option. You can furnish the oscillators with a voltage frequency control that operates over a 5- to 200-MHz range. $98 (10). Delivery, 10 weeks ARO.

Vectron Laboratories Inc, 166 Glover Ave, Norwalk, CT 06850. Phone (203) 853-4433. TWX 710-468-3796.

Circle No 387



FILTERS

- *Insertion loss between 30-kHz and 1-GHz frequencies*
- *Operate over the military temperature range*

DTT Series T-circuit EMI filters have an operating temperature range of −55 to +125°C and are housed in hermetically sealed metal cases, making them suitable for use in the most stringent applications. The cases have a threaded stud at

99.9992% pure sine waves. Within 0.001Hz.

High speed at high purity makes this easy-to-use high precision Bruel & Kjaer 1051 sine generator the instrument of choice for ADC characterization, product or system calibration requiring many frequencies/levels.

With distortion less than 0.0008% (−102 dB) in the 20 Hz to 20 kHz range, and frequency accuracy +180/−0 µHz throughout its 1 mHz to 200 kHz operating range, the 1051 combines production-line speed with laboratory-instrument accuracy to give you the best of both in a single integrated package.

You get plenty of convenience features, too. Like easy external control (English language commands) via IEEE-488 interface, a 1024-point amplitude memory, storage of up to 9 user-defined test setups, calibrated output from 100 µV to 5 V, accuracy within 0.05 dB from 20 Hz to 20 kHz, and six-decade log or linear frequency sweep in one continuous range with selectable upper and lower limits.

For ADC characterization, Automated Test Systems, or any kind of product or system calibration application, our 1051 gives you precisely what you've always needed in a sine wave generator — precision. Coupled with what you've always wanted and never had — speed.

For complete information on the 1051 sine generator that's both pure and fast, call Bruel and Kjaer today or circle reader service number.

CIRCLE NO 175

Brüel & Kjær

Bruel & Kjaer Instruments, Inc.

185 Forest Street, Marlborough, MA 01752 USA • Telephone 508/481-7000

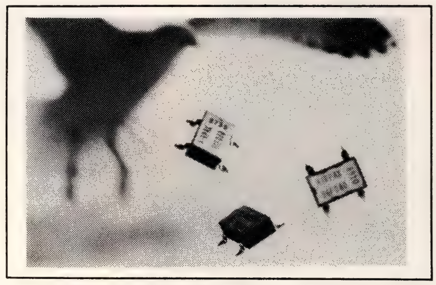
WORLD HQ: DK-2850 Naerum • Denmark • Tel: + 452800500 • Telex: 37316 bruka dk

Australia (02) 450-2006 • Austria 02235/7550*0 • Belgium 02-242-9745 • Brazil 11-246-8166 • Canada (514) 695-8225 • Finland (90) 8017044 • France (1) 64572010 • Federal Republic of Germany (04106) 4055 • Holland 03402-39994 • Hong Kong 5-487486 • Italy (02) 5244141 • Japan 03-438-0761 • Republic of Korea 02-554-0605 • Norway 02-787096 • Singapore 2258533 • Spain (91) 2681000 • Sweden (08) 7112730 • Switzerland (042) 651161 • Taiwan (02) 7139303 • United Kingdom (01) 954-2366 • USA (508) 481-7000 • Local representatives and service organizations world-wide.

one end that allows you to bulkhead mount the filters, in which case the coaxial input and output leads are situated on opposite sides of the bulkhead to provide feedthrough operation. They are available with voltage ratings as high as 530V dc, and 375V ac at 400 Hz, with maximum continuous line current ratings between 1 and 10A. At temperatures above 105°C, you must derate the line current rating linearly to 60% of this maximum value. The insertion-loss performance of the filters is specified over a frequency range of 30 kHz to 1 GHz, and these specifications are guaranteed at the full line-current rating. The filters conform to BS-9121-F0011 requirements and have additional assessment-level approval. Approximately £12 (1000).

Beck Electronics Ltd, Main Cross Rd, South Denes, Gt Yarmouth, Norfolk NR30 3PX, UK. Phone (0493) 856282. FAX 0493-850169.

Circle No 388



THERMOSTATS

- *Surface mountable*
- *Have a rating of 1A at 48V*

The Series 6600 bimetallic thermostats are housed in gull-wing, leaded packages that are the same size as an 8-pin DIP. They have an spst, gold-plated contact that's available in either a normally open or normally closed configuration. The contact has a rating of 1A (resistive) at 48V dc. The thermostats can sense over a 40 to 120°C ambient temperature range in 5°C increments. The thermostats are compatible with pick-and-place equipment and are sealed to withstand wave-soldering and board-washing processes. $3.30 (500). Delivery, stock to eight weeks ARO.

Airpax, Husky Park, Frederick, MD 21701. Phone (301) 663-5141.

Circle No 389

AMPLIFIER

- *Designed for fiber-optic applications*
- *Operates from a single supply*

The ACT-4032 amplifier is suited to high data-rate fiber-optic applications. It has a 0.1- to 4000-MHz bandwidth, a 19-dB gain, a ±½-dB full-band gain flatness, a 15% max

Text continued on pg 230

Protect your power supply with as little as this.

It's called the Littelfuse subminiature 2AG glass fuse. And considering what they can do to protect your product designs, they just might be the most affordable and dependable forms of product insurance you can have working for you.

That's because we've combined all the performance benefits you've come to expect from our 3AG fuses (.250″ x 1.250″), and designed them into a new 2AG fuse package that's only one-third the size of a 3AG fuse.

Measuring just 0.58″ in length, with a diameter of only 0.177,″ the Littelfuse 2AG fuse is perfect for crowded printed circuit boards, telecommunications equipment and other applications requiring reliable, space-saving, economical protection.

You can choose Slo-Blo® or fast-acting performance characteristics from ¼ through 7 amperes, 250 volts or less. Each has been listed by UL and Certified by CSA. MIL spec approvals, also available.

Order them with leads for direct soldering into the circuit or in cartridge style for use with mating fuse clips, Shock-safe panel fuse-holders or Omni-Blok™ fuse blocks.

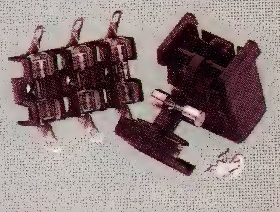
Talk to your local Littelfuse representative or distributor for complete details, samples and prices. Or call (312) 824-1188 for your free product bulletins on the complete 2AG family of circuit protection components.

Littelfuse®
a subsidiary of **Tracor**

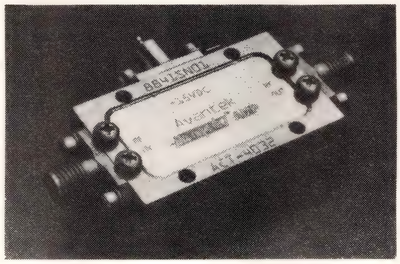
800 E. Northwest Highway • Des Plaines, IL 60016
(312) 824-1188

CIRCLE NO 112

Talk to Littelfuse.



pulse overshoot, and a 1.8:1 max input and output VSWR. The amplifier's internal circuitry consists of three stages of amplification, complete with interstage tuning, I/O matching, and blocking capacitors. The unit is housed in a hermetic flatpack that you can use with RF connectors or install directly in a



50Ω microstrip environment. The amplifier requires a supply of 15V at 105 mA and has a −55 to +85°C operating range. $850 (10).

Avantek Inc, 3175 Bowers Ave, Santa Clara, CA 95054. Phone (408) 943-4296.

Circle No 390

POLYMER

- *Improves contact reliability*
- *Forms no physical bond*

Stabilant 22 is an initially nonconductive block polymer that becomes conductive when applied to an electrical field and/or when used in a narrow gap between metal contacts. The electric field gradient at which the transformation occurs is set so the material will remain nonconductive between adjacent contacts in a multiple-pin environment. When applied to the contacts, Stabilant 22 provides the connection reliability of a soldered joint without bonding the contact surfaces together. The material is available in 0.015-, 0.05-, 0.1-, 0.25-, 0.5-, and 1-liter containers. From $64.50 (OEM qty).

D W Electrochemicals Ltd, 9005 Leslie St, Unit 106, Richmond Hill, Ontario L4C 3G4. Phone (416) 889-1522.

Circle No 391

OPTICAL LINKS

- *Immune from EMI/RFI*
- *Mount on a bulkhead*

According to the vendor, the Series 6600 analog links can house as many as four independent analog fiber-optic transmitters, receivers, or any combination thereof in a single ⅛-DIN aluminum case; the Series 6600 also provides point-to-point transmission of signals with complete immunity from EMI/RFI, ground loops, and high-voltage isolation problems. Each link within the Series package has independently selectable input and output full-scale voltage ranges of ±1, ±5,

SAFT BATTERIES. ONE FOR ALL. ALL FROM ONE.

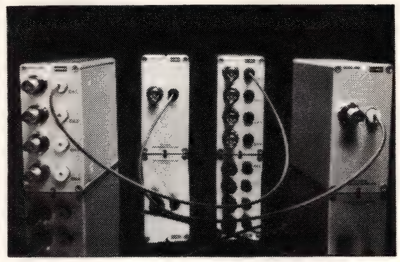
Powering the portable electronics of the 80's has been a major problem for product design engineers. And the 90's will be even more challenging. But there is a one source supplier who can meet almost any portable power design challenge. With the industry's broadest line of Nicad® batteries and a variety of lithium chemistries, SAFT allows today's design engineer to design portability into a broad spectrum of electronics, from simple toys to sophisticated computers. And, best of all, this full range of portable power is available from a single source–one order, one shipment, one invoice.

For more information on our complete line of Nicad batteries, contact SAFT America Inc., Portable Battery Division, 711 Industrial Boulevard, Valdosta, Georgia 31601, or call (912) 247-2331. For information on our variety of lithium chemistries, contact SAFT America Inc., Advanced Battery Systems Division, 107 Beaver Court, Cockeysville, Maryland 21030, or call (301) 771-3200.

CIRCLE NO 113

SAFT

CGE



and ±10V. You use a rear-panel switch to select these ranges; front-panel BNC connectors provide the termination for the analog signals. The design of the DIN case allows you to mount it on a bulkhead or on an optional mounting flange. The links use 1000-μm plastic fiber-optic cable to interconnect the transmitters and receivers. Using a knife or a razor blade, you can readily terminate the cable, which does not require any special epoxy or polishing. A compression-nut-type fitting on the optical port of the transmitters and receivers locks the cable firmly in place. Single-channel configurations, from $160. Delivery, stock to six weeks ARO.

Dymec Inc, 8 Lowell Ave, Winchester, MA 01890. Phone (617) 729-7870.

Circle No 392

POWER MOSFETS

- *Available with drain-current ratings as high as 25A*
- *Can be turned on and off by logic-level signals*

Featuring a maximum gate-threshold voltage of 2.5V, four n-channel enhancement-mode power MOSFETs can be driven by standard 5V logic families. The STLT-19 and STLT-20 have a maximum drain-current rating of 15A and maximum drain-source voltage ratings of 50 and 60V, respectively. Both devices have turn-on and turn-off delay times of 10 and 35 nsec, respectively. The STLT-29 and STLT-30 have a maximum drain-current rating of 25A and drain-source voltage ratings of 50 and 60V, respectively. These devices' turn-on and turn-off times are 25 and 55 nsec, respectively, and they have a static $R_{DS(on)}$ of 0.08Ω. All four devices are housed in TO-220 packages and are available in isolated or nonisolated versions. STLT-19, $0.46; STLT-20, $0.49 (1000).

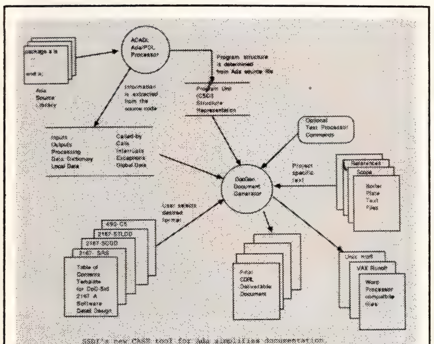
SGS-Thomson Microelectronics, Via C Olivetti 2, 20041 Agrate Brianza, Italy. Phone (039) 65551. TLX 330131.

Circle No 393

SGS-Thomson Microelectronics, 1000 E Bell Rd, Phoenix, AZ 85022. Phone (602) 867-6100. TLX 249976.

Circle No 394

CAE & SOFTWARE DEVELOPMENT TOOLS



SSDI's new CASE tool for Ada simplifies documentation.

CASE TOOL

- *Extracts data from Ada source files*
- *Correlates the data to satisfy DoD-STD-2167A requirements*

DocGen accesses Ada source-code files, analyzes all Ada statements, and identifies the information required by DoD-STD-2167A, such as inputs and outputs, local and global variables, interrupts, subroutine calls, and exception handlers. The program then formats the information according to the standard's requirements. It can also analyze and document Ada pseudo-codes, which are high-level descriptions of entire algorithms. DocGen works on three specific types of files: the Program Unit Structure file, which is a list of all Ada modules in the design; the Intermediate Documentation file, which contains raw, unformatted information drawn from the source files; and the Table of Contents template. The program runs on VAX, Apollo, Sun, Hewlett-Packard, Data General, Gould, Harris, and other computers, as well as under a variety of operating systems. $6950.

Software Systems Design Inc, 3627 Padua Ave, Claremont, CA 91711. Phone (714) 625-6147.

Circle No 400

SECURITY SYSTEM

- *Analyzes typing patterns to provide user identification*
- *Can verify legitimate log-on by the current user*

Electronic Signature Lock (ESL) is a biometric user-identification technology that provides positive identification of a local or remote terminal user. You can attach a hardware version to a mainframe; on IBM PCs and compatibles or a workstation, a software version with less security requires no additional hardware. ESL assigns electronic signatures to a user, based upon statistical filtering of unique key-

stroke dynamics and typing patterns. The analytical algorithms take into account variations in these patterns that are caused by local circumstances. Once a user has provided a reference signature (usually by typing a name or a set phrase several times for initial authorization), the program will thereafter grant easy access to the computer, providing that the individual uses the proper passwords or meets the other security requirements of the system. The program will deny access to unauthorized persons, even those who use the name and passwords of an authorized user. A more complex version (CESL) can monitor a user continuously, determine that the current user is the same one who was given access at log-on, and even detect symptoms of stress. From $500 for a PC-DOS software-only version.

Electronic Signature Lock Corp, Box 10851, Eugene, OR 97440. Phone (503) 937-3437.

Circle No 401

LANGUAGE EDITOR

- *Integrates vendor's C and Pascal compilers with VAX LSE*
- *Helps find and correct compilation errors quickly*

The BSO/LSE+ user-interface package integrates the vendor's Pascal and C compilers, assembler, and symbolic debugger with the VAX Language-Sensitive Editor (LSE) and with other VAX software-development tools. The package also provides comprehensive on-line help for general language-related questions or for specific inquiries about LSE templates and their elements. The VAX LSE provides C and Pascal programmers with a fast and efficient way to enter source code, while automatically eliminating many routine errors such as a missing semicolon, unmatched parentheses or braces, and many common syntax errors. Without leaving BSO/LSE+, you can then compile, assemble, link, and debug your program. You can also execute normal VAX DCL commands, and a dual-window feature lets you edit a file in one window, while executing DCL commands or reading MAIL in the other; it also lets you execute your program in one window, while viewing the associated source code in the other. BSO/LSE+ runs on any VAX model under version 4.4 or higher of the VMS operating system; you also need version 2.2 or higher of the VAX LSE. From $500.

Boston Systems Office, 128 Technology Center, Waltham, MA 02254. Phone (617) 894-7800. TWX 710-324-0760.

Circle No 402

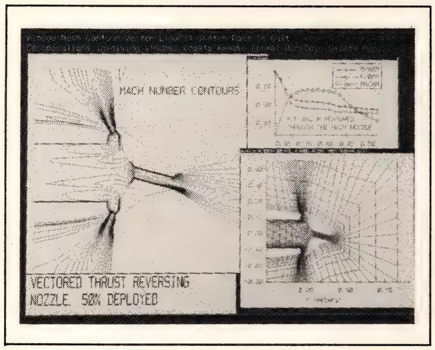
RULE CHECKER

- *Eliminates redundant errors*
- *Lets you use Boolean operators*

The LRC-100 Layout Rule Checker works with the vendor's LTL-100/SUN pc-board-design package. You can check all your layout rules in batch mode. You can also interactively select specific design rules for checking, view error vectors, edit the structure, and recheck. The LRC-100's hierarchical checking structure eliminates redundant errors. Its basic capabilities include width checks, spacing checks within a layer or between layers, and internal and external notch checks. You can also verify areas using the intersect, enclosure, and overlap capabilities. You can define rules with the Boolean operators (AND, ANDNOT, OR, and XOR), as well as by path length. In addition, the LRC-100 offers a perimeter check. The package runs on SUN 386i workstations. $9850.

Integrated Silicon Systems Inc, Box 13665, Research Triangle Park, NC 27709. Phone (919) 361-5814.

Circle No 403

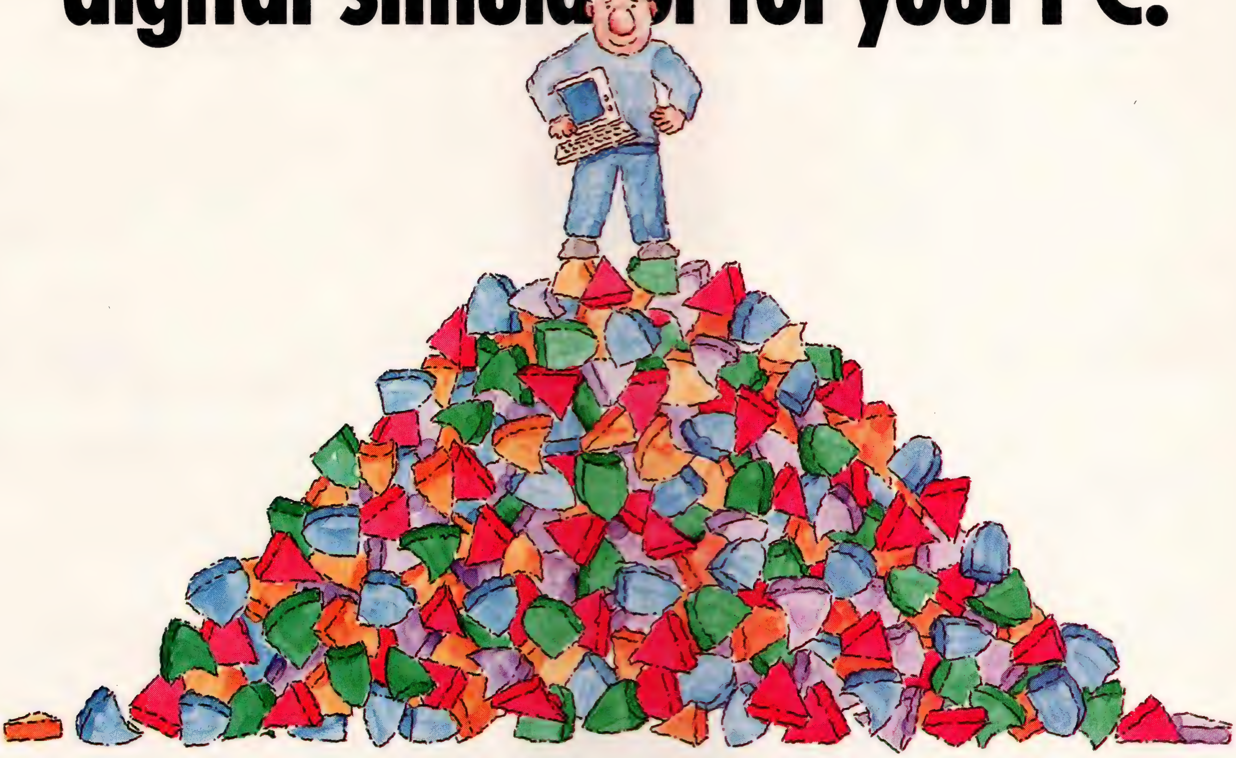


PLOTTING SOFTWARE

- *Lets you create windows for plotting multiple data sets*
- *Menus guide you through procedures for creating plots*

TECPLOT is an interactive plotting program for visualizing technical data in the form of contour lines, color-flooded contours, vector fields, streamlines, and X-Y plots. It runs on Apollo workstations and IBM PCs and compatibles. You can create multiple windows, and each window can use either a unique data set or data from a previous window. You can partition a data set into zones, and each zone may contain all or part of the data for a particular plot. On the Apollo, there's no limit on the size of a data set; on the IBM PC/XT or PC/AT you can display as many as 20,000 data points. Menus guide you through the procedures needed to create plots, and you can interrupt the plotting process at any time to change parameters and see the results of the change. You can obtain hard copy of your plots on pen plot-

MICRO-LOGIC II.™
The CAE tool with a 10,000-gate digital simulator for your PC.



Spectrum Software's MICRO-LOGIC II® puts you on top of the most complex logic design problems. With a powerful total capacity of 10,000 gates, MICRO-LOGIC II helps engineers tackle tough design and simulation problems right at their PCs.

MICRO-LOGIC II, which is based on our original MICRO-LOGIC software, is a field-proven, second-generation program. It has a high-speed event-driven simulator which is significantly faster than the earlier version.

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The program provides you with a top-notch interactive drawing and analysis environment. You can create logic diagrams of up to 64 pages with ease. The software features a sophisticated schematic editor with pan and zoom capabilities.

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A 200-type library of standard parts is at your fingertips. And for a new high in flexibility, a built-in shape editor lets you create unique or custom shapes.

MICRO-LOGIC II is available for the IBM® PC. It is CGA, EGA, and Hercules® compatible and costs only $895 complete. An evaluation version is available for $100. Call or write today for our free brochure and demo disk. We'd like to put you in touch with a top digital solution.

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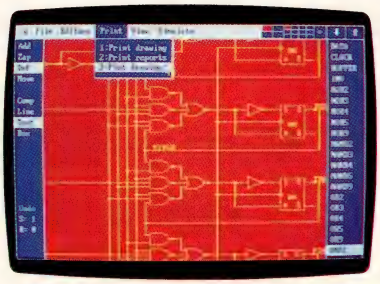

Schematic Editor

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EATON

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ters or PostScript-compatible laser printers. On IBM PCs and compatibles, you'll need at least 512k bytes of RAM and an EGA- or VGA-compatible graphics card. Prices start at $695 for the PC version.

Amtek Engineering Inc, 11820 Northup Way, Suite 200, Bellevue, WA 98005. Phone (206) 827-3304.

Circle No 404

WINDOWING TOOL

- *Lets you establish windows for multiple Unix applications*
- *Runs on 80386-based Unix machines*

The Xsight windowing system runs on 80386-based computers under Unix System V, Release 3. The package lets you divide your screen into multiple windows, each of which runs a different Unix application program. The package works with the vendor's Merge 386, which allows you to run DOS applications and Unix applications concurrently on 80386-based systems. If your personal computer is networked to a Unix host, Xsight lets you call up, monitor, and control multiple DOS and Unix applications on any node in the network. $695.

Locus Computing Corp, 9800 La Cienega Blvd, Inglewood, CA 90301. Phone (213) 670-6500. FAX 213-670-2980.

Circle No 405

TOUCHSCREEN DRIVER

- *Lets you modify a program to accept touch input*
- *Captures and inserts graphics images in text-based applications*

TouchBack lets you modify any application program that you've built with dBASE, Show Partner/FX, or a Basic interpreter or compiler, to accept input from one of the vendor's touch screens. You need only add two lines of code for each display screen. TouchBack also works with the vendor's application-development system, TouchUp, which lets you take snapshots of any screen generated by an application program, and then define touch-zone boundaries merely by tracing those boundaries with your finger. The program also allows you to capture CGA-, EGA-, VGA-, or Hercules-compatible graphic images and insert them into text-based displays such as those generated by dBASE. $99.

Elographics Inc, 105 Randolph Rd, Oak Ridge, TN 37830. Phone (615) 482-4100.

Circle No 406

TEST & MEASUREMENT INSTRUMENTS

80C537 EMULATOR

- *Operates to 12 MHz*
- *Uses high-speed parallel interface to host PC*

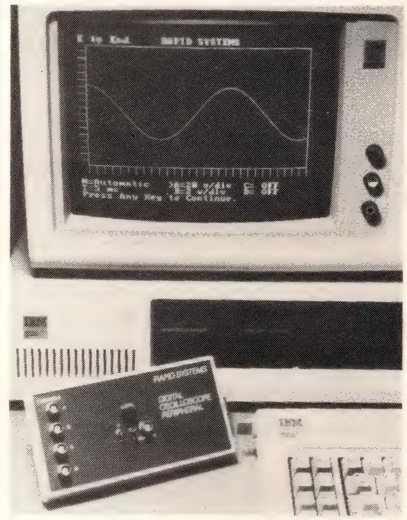
The Emul51-PC coupled with the Pod-537 is a 12-MHz in-circuit emulator for the Siemens 80517 and 80537 8-bit CMOS microcontrollers. The 80537, housed in an 84-pin PLCC, is based on Intel's 8051 architecture; the 80517 is similar to the 80537 but adds an 8k-byte ROM. Among the processors' features are a 32-bit hardware multiply/divide unit, a 12-input 8-bit ADC, two full-duplex serial ports, and nine parallel ports, of which seven are 8-bits wide and bidirectional. The Emul51-PC is a plug-in card for the IBM PC bus that makes parallel data transfers at high speed. A second card for implementing the trace function is optional. $2190.

Nohau Corp, 51 E Campbell Ave, Campbell, CA 95008. Phone (408) 866-1820.

Circle No 411

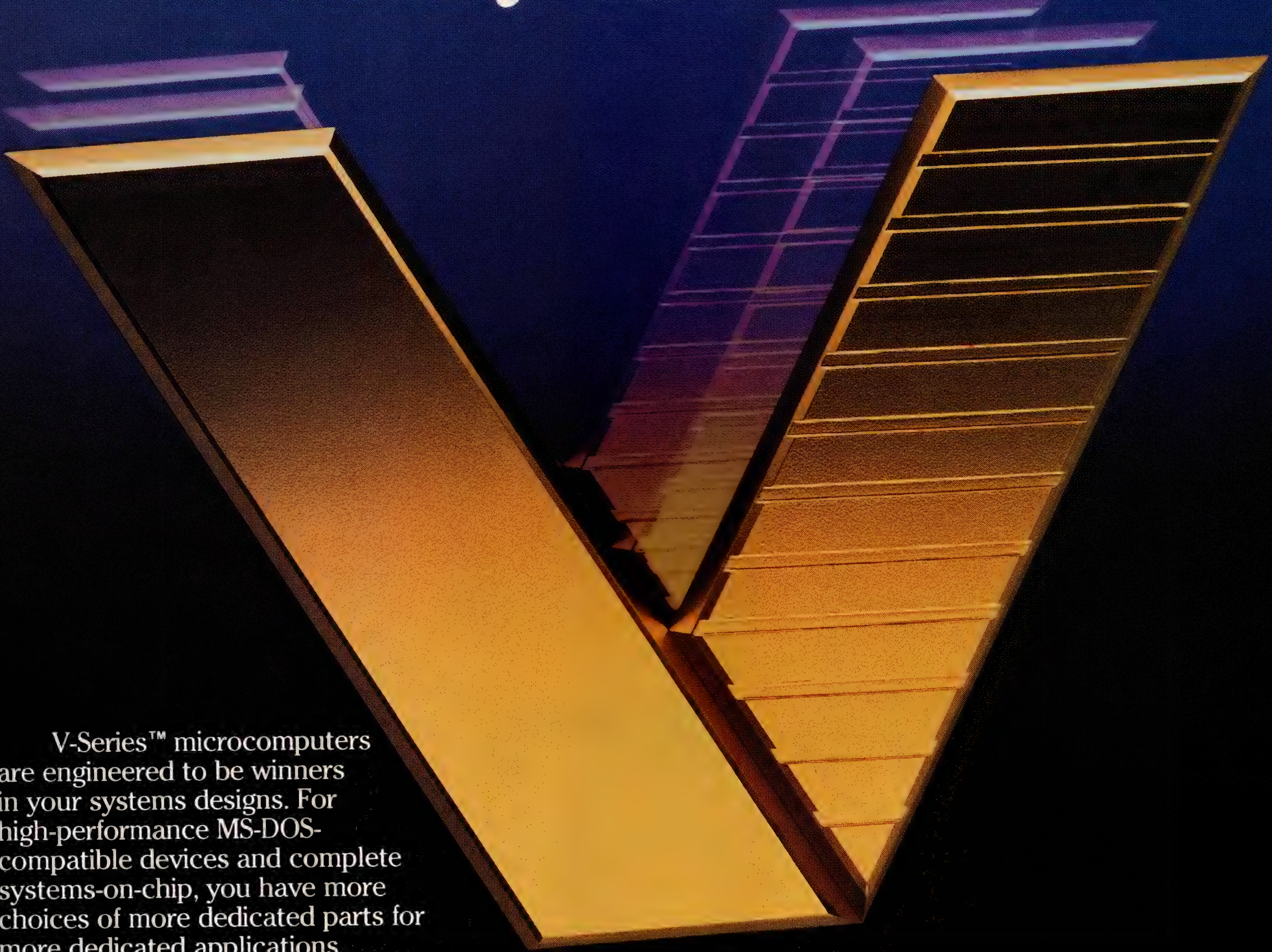
PC DIGITAL SCOPE

- *Converts PCs into 4-channel data-acquisition units*
- *Includes hardware, software, and source code*



The R414 is a digital oscilloscope peripheral for IBM PCs, PC/XTs, PC/ATs, and compatible computers. It features selectable sample rates from 1 to 500 kHz and allows you to select the gain from 10 mV to 320V p-p for 8-bit accuracy. You can set the scope for either internal or external analog triggering; it has a 2048-point data memory. The inputs are diode protected and accept BNC connectors. You can program the R414 in C, Turbo Pascal, or Basic. The user's manual contains sam-

V-Series
a victory for the user.



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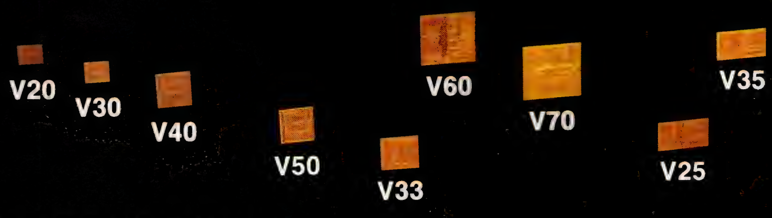

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ple program listings. Optional features include enhanced oscilloscope-display software, spectrum-analysis software, and digital-signal-processing hardware. $295.

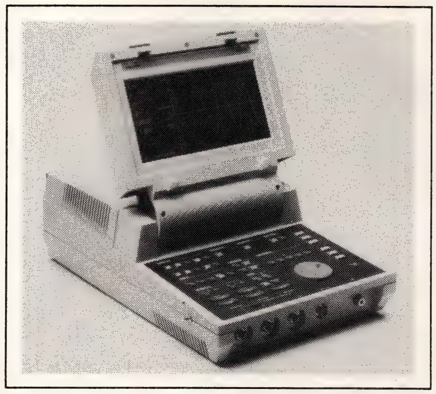
Rapid Systems Inc, 433 N 34th St, Seattle, WA 98103. Phone (206) 547-8311. TLX 265017.

Circle No 412

PORTABLE DSO

- *Uses electroluminescent display*
- *Stores 100 waveforms in nonvolatile RAM*

The PM 3308 digital storage oscilloscope takes 40M samples/sec max. It has two vertical inputs whose bandwidth is 100 MHz. Using an electroluminescent screen, the



scope can display four waveforms, two of which are computed. Cursors make possible such measurements as voltage difference, rms voltage, p-p voltage, average dc level, rise time, period, and phase. Consequently, you won't need a separate DMM and counter in many applications. Regardless of the sweep speed, the scope will capture 10-nsec glitches. A 180k-byte nonvolatile RAM "disk" stores a combination of 100 waveforms and setup menus; the scope can transmit the waveform data through RS-232C and IEEE-488 ports. A real-time clock records the date and time of waveform acquisition. $7500. Delivery, eight weeks ARO.

John Fluke Mfg Co Inc, Box C-9090, Everett, WA 98206. Phone (800) 443-5853, ext 77. TLX 185102.

Circle No 413

Philips Test and Measurement, Bldg HKF, 5600 MD, Eindhoven, The Netherlands. Phone local office.

Circle No 414

CALCULATOR

- *Includes library of popular programs*
- *Allows keystroke programming*

The HP 20S is a keystroke-programmable scientific calculator that offers all of the capabilities normally associated with under-$50 units and which, in addition, provides a library of functions usually associated only with higher-priced units. Included are routines for integrating, finding roots, fitting

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PADS SUPERSTATION™

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The Integrated PADS-Superstation™ is a new and powerful PC-Based Design Station that allows the Engineer or Circuit Designer to perform the entire design sequence from cradle-to-grave. Every decision required in the design effort, from Logic Capture to Printed Circuit Design, to 100% Connection Routing, to Checking, to generating Manufacturing Aids is made by the responsible engineer and implemented on a single, fully integrated CAE/CAD SUPERSTATION!

LOGIC CAPTURE

The PADS-CAE system maximizes Logic Capture automation, while allowing the engineer to concentrate on the design task. This high degree of automation results from the use of a new type of database: A Design-Oriented-Database. All drawing sheets of the design are simultaneously available - not merely a single sheet, as with most other Logic Capture systems.

Among the many advantages of this new database are Automatic (hands-off) entry of Reference Designation, gate and pin data, on-line real time data checking across all drawing sheets, rapid paging from sheet-to-sheet, and instantly available (no batching) Annotation Lists to both PADS-PCB and other board CAD systems using FUTURE NET™.

The most tedious and error-prone phase of Engineering Documentation, i.e., Engineering Change Order (ECO), is easy with PADS. ECOs generated in either the Schematic, or the Board database are used to automatically (hands-off) update the corresponding database.

BOARD DESIGN

PADS-PCB is today's most popular board CAD System and is the heart of the Superstation. PADS-PCB has revolutionized Printed Circuit Board CAD expectations by demonstrating an alternative to today's $100,000 Work Stations. Thousands of designers, engineers, and Board Design Centers use PADS-PCB - and for good reasons: 1 mil resolution, 30 layers, large board (over 400 14 pin ICs per board), complete SMD support, fine line (1, 2 & 3 tracks between IC pins), both Analog & Digital capability, fast Air Gap & Data checking, Gate & Pin swapping, dynamic rubber banding, rats' nest display, interactive and auto placement, interactive & auto routing, and all required Manufacturing Aids (CAM).

PADS-PCB is tightly coupled, both to and from PADS-CAE, and from other Logic Capture systems using FutureNet™.

100% COMPLETION AUTOROUTING

The most demanding phase of board design is routing the connections; approximately 70% of the board design effort is spent in this time consuming, labor-intensive task. Every Designer and Engineer's dream is to have a 100% completion autorouter, and PADS-Superrouter™ brings this capability to the Superstation™.

Here's how it works: the Designer places the components on the board, selects the "Route" command, and the SUPERROUTER takes over, routing around the clock, hour after hour, performing this tedious task to completion, or near completion, while the Designer is involved in other tasks. It's that easy! PADS-Superrouter allows the designer to set up a routing strategy based upon the requirements of each board. A costed Maze Search algorithm, using obstacle hugging on a 10, 20, 25 or 50 mil grid, and up to 12 simultaneous layers attempts to achieve 100% completion. A Rip-up-and-Retry Algorithm is used to obtain this objective.

Following routing, an Ease-of-Manufacturing Optimizer prepares the board for maximizing the manufacturing yield. Bends and curves put in by obstacle hugging are removed, closely spaced tracks are unpacked, corners are made at 45°, and all possible Vias are removed. The results equal or exceed that of the most experienced board designer.

LOW PRICE

While the performance and functionality of the PADS-SUPERROUTER is equal to any Workstation at any price, its price is competitive with the very low cost PC-based CAD systems. The price has been structured to allow every engineer in the organization to have his/her own personal SUPERSTATION™.

EVALUATION PACKAGE

So that you can appreciate the impact the PADS-Superstation™ will have in your organization, we have created a Superstation Evaluation Package. It is available at no cost to qualified engineers and designers. Please call our Sales Department at (800) 255-7814; Inside Mass. (508) 486-9521.

CAD

CAD Software, Inc.
Suite #6
119 Russell Street
Littleton, MA 01460

CIRCLE NO 119

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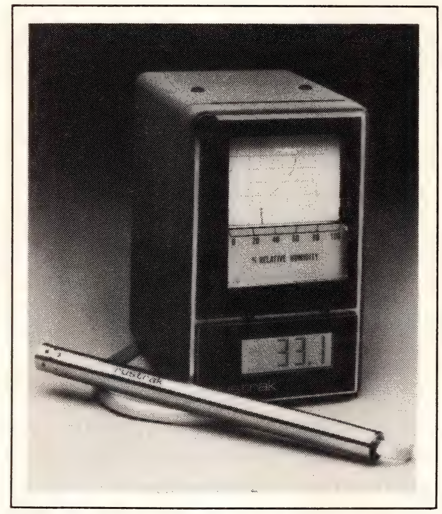
INSTRUMENTS

curves, solving quadratic equations, and operating on complex numbers and 3×3 matrices. Programs can incorporate conditional tests and can perform base conversion. The HP 10B, a companion unit intended for business use, is priced the same as the HP 20S. $49.95.

Hewlett-Packard Co, 1000 NE Circle Blvd, Corvallis, OR 97330. Phone (800) 752-0900, dept 164L.

Circle No 415



HUMIDITY RECORDER

- *Uses probe that recovers from water immersion*
- *Records measurements for up to 250 days*

The Digilog-26 strip-chart recorder measures and records relative humidity on a 2.3-in. chart. The instrument features an LCD readout and a probe that you can place as far as 99 feet away from the recorder for remote operation. The probe's response time is less than 2 sec from 45 to 95%. The probe's mosaic surface provides self-filtering of particles. The self-contained, 7-segment reflective LCD allows you to see the relative humidity while the recorder prints the data on the strip chart. $735.

Rustrak Instruments, Route 2 and Middle Rd, East Greenwich, RI 02818. Phone (800) 332-3202. TWX 710-387-1500.

Circle No 416

ASIC EVALUATOR

- *Outputs vectors at 50 MHz*
- *Upgrades to permit a 200-MHz vector rate*

The HP 82000 Model D50 is an ASIC evaluation system with tester-per-pin architecture. It can handle devices having from 64 to 512 pins. Its maximum vector-output speed is 50 MHz, its edge-placement accuracy is ±500 psec, and its maximum vector depth is 256k frames. Systems with 160 or fewer pins fit in a benchtop cabinet. Upgrades to the vendor's recently introduced HP 82000 Model D200, with 200-MHz maximum vector-output speed, involve changing only one mechanical housing. From $70,000; with 256 I/O channels, $240,000.

Hewlett-Packard Co, 19310 Pruneridge Ave, Cupertino, CA 95014. Phone local sales office.

Circle No 417

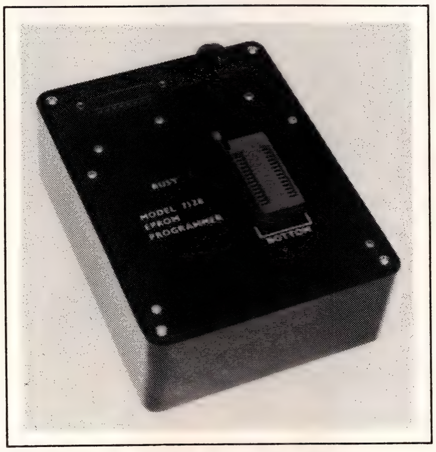
IEEE-488 INTERFACES

- *Work with Apple Macintosh computers*
- *Access instruments via user programs or desk accessory*

A line of IEEE-488 interfaces for Apple's Macintosh computers includes a Nubus board for the Macintosh II and IIx, the MacII488; a SCSI-interfaced unit, the MacSCSI488; a unit that connects to the RS-422 port, the Mac488B; and an interface for IEEE-488 plotters, the MacSerial488. Included with the hardware is the MacDA488, a desk accessory that lets you create and execute procedures that control instruments and acquire data via the IEEE-488 bus. Also included is the MacDriver488, a driver which lets you perform the same functions from within programs you write in C, Basic, Pascal, and Hypertalk. A separate software package, MacPlot, works with the plotter interface to control hard-copy graphic-output devices. Hardware units, $495 to $795; MacPlot, $395.

IOtech Inc, 25971 Cannon Rd, Cleveland, OH 44146. Phone (216) 439-4091. TWX 650-282-0864.

Circle No 418



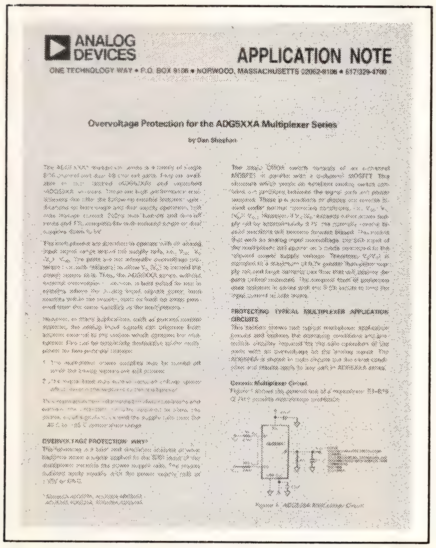
EPROM PROGRAMMER

- *Uses no personality modules*
- *Programs only those locations that contain new data*

The 7128 is an EPROM programmer with an internal μP. You use it with an external terminal or computer emulating a terminal. The unit's firmware presents a menu of EPROM types, and when you choose one, it automatically configures the unit for the selected device's pinout and program voltages. The programmer uses no personality modules and includes a fast-programming mode that writes new data into only those locations whose data after programming will differ from the current contents. $450.

Entertron Industries Inc, 3857 Orangeport Rd, Gasport, NY 14067. Phone (716) 772-7216. FAX 716-772-2604.

Circle No 419



App note explains overvoltage protection

This 2-pg application note, *Overvoltage Protection for the ADG5XXA Series of Multiplexers,* analyzes the problems involved and the protection required in two typical multiplexer applications. It features the vendor's ADG5XXA Series multiplexers and describes protection circuitry that allows analog input signals to exceed the supply rails from −40 to +85°C. Topics covered include protecting typical multiplexer application circuits, and the advantages of external protection.

Analog Devices, Literature Center, 70 Shawmut Rd, Canton, MA 02021.

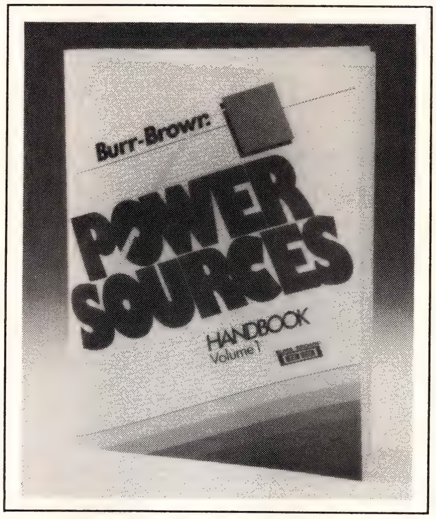
Circle No 420

Exploring the benefits of network licensing

The 300-pg report, *License Servers: New Pricing and Marketing Possibilities for Software on a Network,* examines the new technology of network licensing that allows applications (or licenses to use applications) to be easily moved around on a network. According to the vendor, this report is the only source with so much information so clearly defined on this technology. The paper shows that by using network licensing, users are no longer restricted to using software on a single, predefined computer; instead, users can easily share software, thus freeing up software budgets for the purchase of new types of software, or for hardware products, such as workstations. $5000.

Marketshare Inc, 21 Cochituate Rd, Wayland, MA 01778.

INQUIRE DIRECT



Handbook features power sources

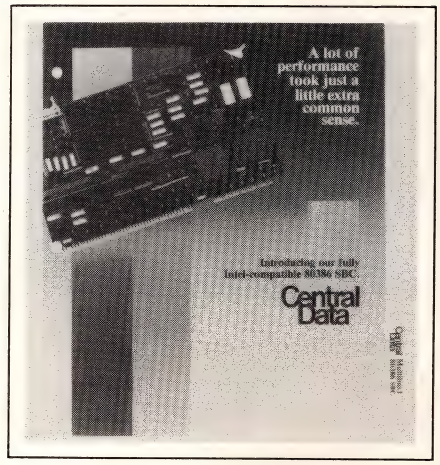
Power Sources Handbook presents more than 450 single-, dual-, and triple-output power supplies in a wide range of modular packages and DIPs. The 96-pg guide provides product data sheets for the vendor's power-conversion products. Supplementary data includes a selection guide, a discussion of advanced reliability programs, a glossary of power-conversion terms, and application notes.

Burr-Brown, Box 11400, Tucson, AZ 85734.

Circle No 421

Brochure comments on single-board computer

This 6-pg brochure illuminates the vendor's Intel-compatible Multibus I 80386 single-board computer. The 4-color publication features photographs, a technical description, and complete specifications for the



CD21/8386 SBC, which features items not found on Intel's board, such as two SBX connectors, onboard sockets for both the 80387 and Weitek 1167 numeric processors, and onboard DMA.

Central Data, 1602 Newton Dr, Champaign, IL 61821.

Circle No 422

Listing of electrical test and measurement instruments

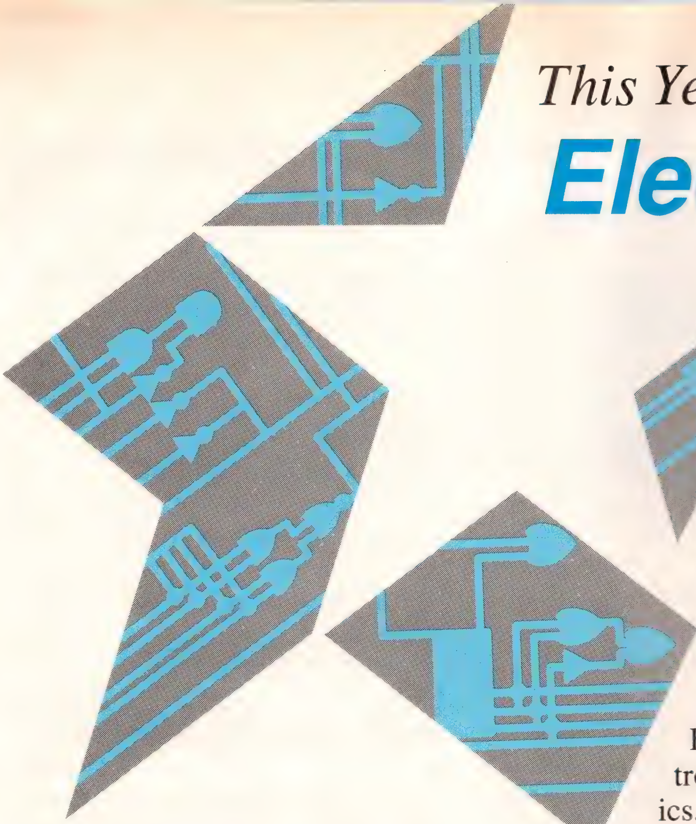
This 10-pg booklet lists a variety of test and measurement instruments, including the Megger insulation test instruments, Megger earth-resistance testers, cable-fault locating equipment, TTR transformer turn-ratio test sets, power-factor test sets, and several portable instruments. The 4-color brochure provides an illustration for each device.

Biddle Instruments, 510 Township Line Rd, Blue Bell, PA 19422.

Circle No 423

Direct digitization of transducers noted

AN7: Some Techniques for Direct Digitization of Transducer Outputs offers advice on how to solve transducer-output digitizer problems. To help you find solutions, the 16-pg note features schematics of circuits for temperature-to-frequency conversion, thermocouple-to-frequency conversion, an acoustical thermometer, a strain-gauge



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CIRCLE NO 115

digitizer, a photodiode digitizer, and humidity-to-frequency conversion.

Linear Technology Corp, 1630 McCarthy Blvd, Milpitas, CA 95035.

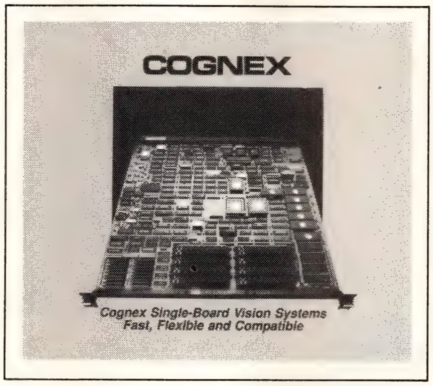
Circle No 424

Report on surface treatment

The vendor's 4-pg report explains Ionguard, an innovative approach for changing the mechanical and chemical surface properties of metals, composites, ceramics, glass, and plastics. The 4-color publication outlines the applications, advantages, and features of the process and lists the services provided by the vendor. Photographs and charts enhance the brochure's discussion.

Spire Corp, Patriots Park, Bedford, MA 01730.

Circle No 425



Booklet unveils vision systems

Featuring the vendor's 3000 Series single-board vision systems, the 6-pg foldout brochure highlights the gray-scale image processing feature, which, according to the company, allows the systems to perform image analysis and pattern recognition in varied light conditions. An applications section lists uses for the systems in the semiconductor, electronics, aerospace, pharmaceutical, and general manufacturing industries.

Cognex Corp, 72 River Park St, Needham, MA 02194.

Circle No 426

Primer explains use of 11300A Series scopes

The *11300A Series Timing Measurement Primer (47W-6783),* instructs you on how to make 10 timing measurements, including propagation delay, pulse interval, and total (event counting) measurements, using the company's 11300A counter/timer oscilloscopes. The 24-pg publication also has a reference page that shows how to set up the oscilloscope for different measurements, as well as a glossary and a troubleshooting checklist.

Tektronix Inc, Box 500, Beaverton, OR 97077.

Circle No 427

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‡In MA (617) 661-0072.

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CIRCLE NO 116

Pamphlet surveys software for IBM PC and PS/2 Series

The vendor's brochure introduces Lotus Measure data-acquisition and instrument-control software for IBM PC, PC/XT, PC/AT, PS/2, and compatible computers. The 6-pg foldout pamphlet illustrates how Measure acquires data, and how you can manipulate and present the data once it is acquired. The publication also details the technical background information, illustrated with screen displays.

National Instruments, 12109 Technology Blvd, Austin, TX 78727.

Circle No 429

Inventory of technical books for engineers

The 1989 Publications Catalog of the IEEE Computer Society provides a voluminous listing of professional-level technical books for computer scientists and engineers. Sixty new books have been added to the list since the publication of the 1988 catalog. The 28-pg publication is divided into sections entitled Coming Soon from CS Press, Monographs (a new category), Tutorials by Subject, Conference Records & Proceedings, Special Book Packages, ANSI/IEEE Standards, Master Publications Listing & Price List, and Membership Information.

The IEEE Computer Society, 1730 Massachusetts Ave NW, Washington, DC 20036.

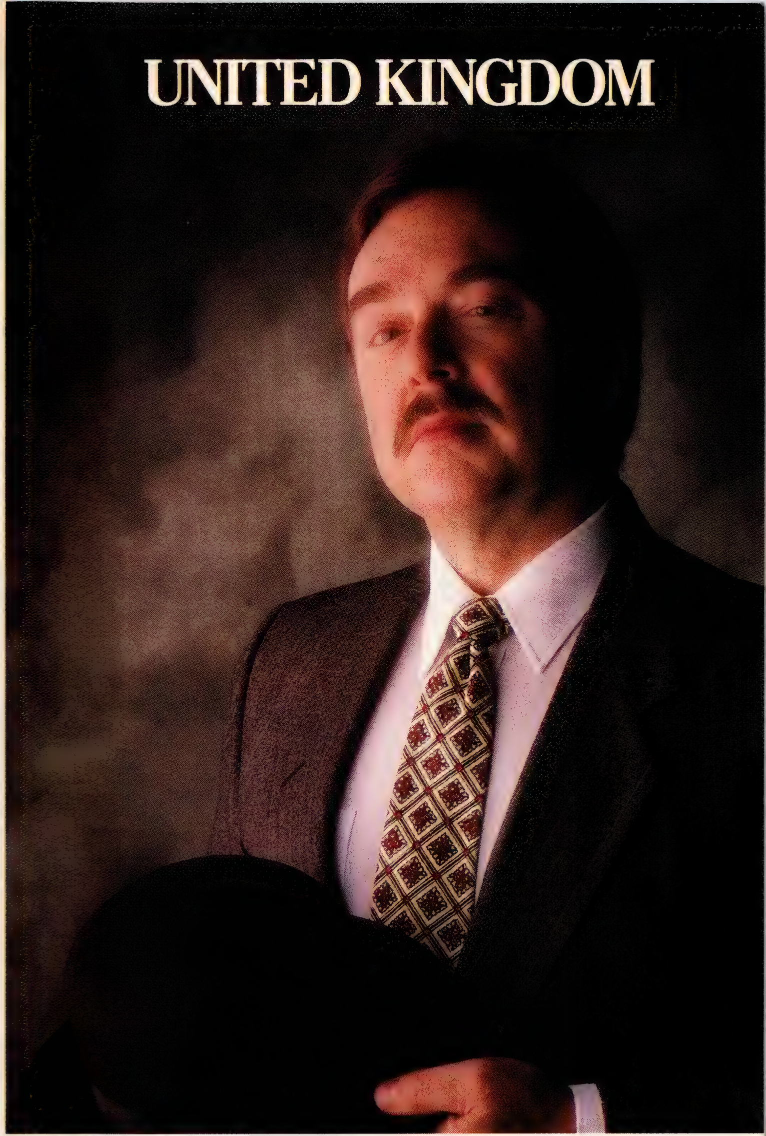
Circle No 430

Disk illustrates debugging techniques

Using an actual emulation session as an example, the vendor's demonstration disk provides a hands-on introduction to symbolic and source-level debugging. The training disk uses graphics to explain each window and gives instructions on how to use an emulator to find software bugs.

Softaid Inc, 8930 Rte 108, Columbia, MD 21045.

Circle No 431



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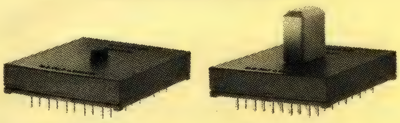

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☆ ☆ ☆ ☆
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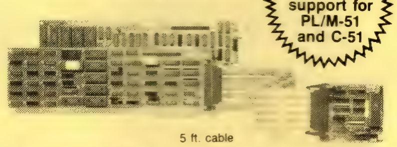

5 ft. cable

8051

See EEM 88/89 Page D-1304

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- Pull-down menus combined with Command-Driven User Interface. Context sensitive help and On-Screen Editing of data
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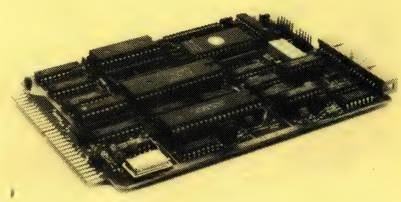

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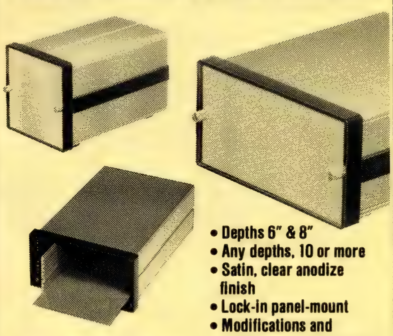

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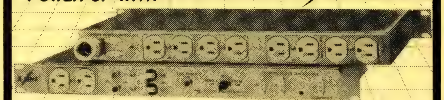

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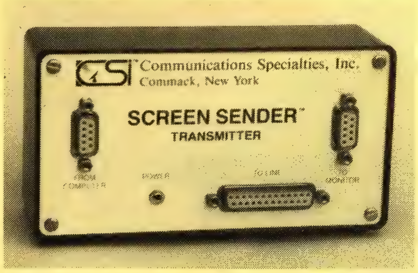

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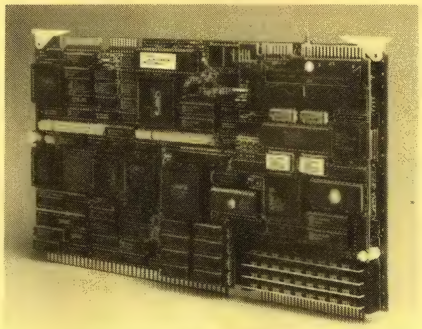

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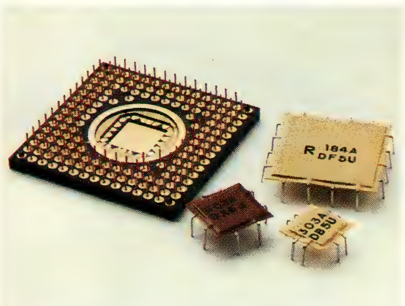

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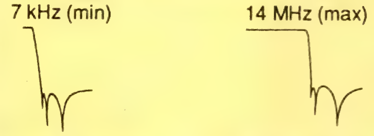

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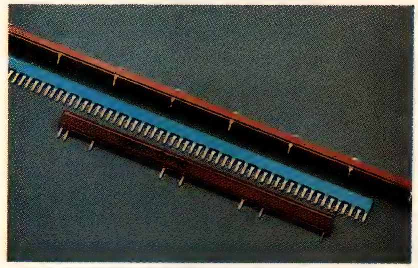

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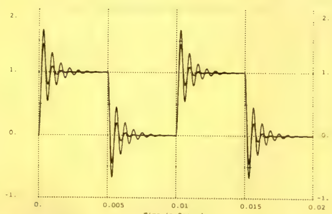

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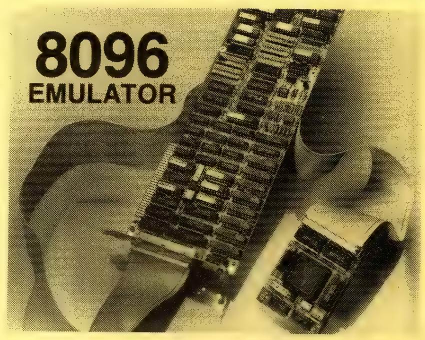

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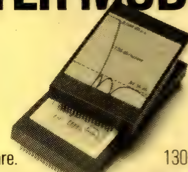

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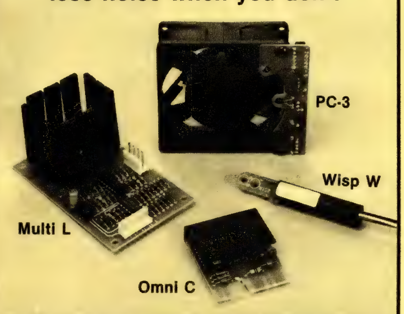

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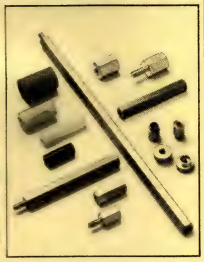

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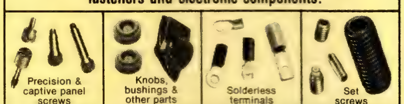

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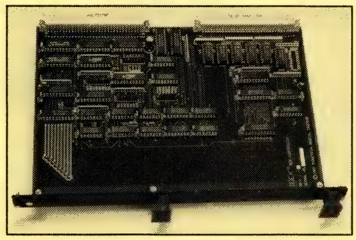

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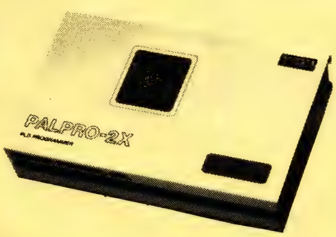

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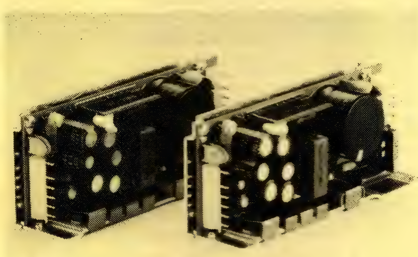

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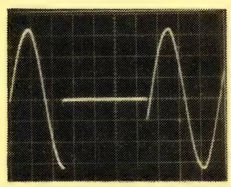

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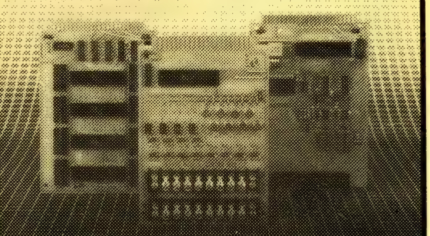

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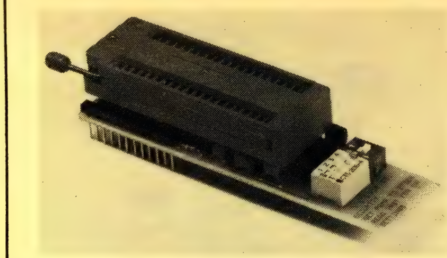

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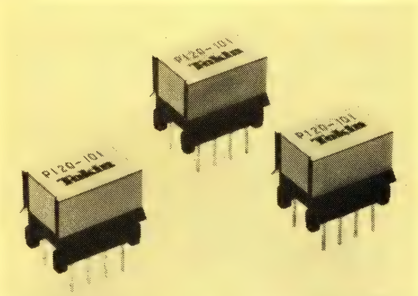

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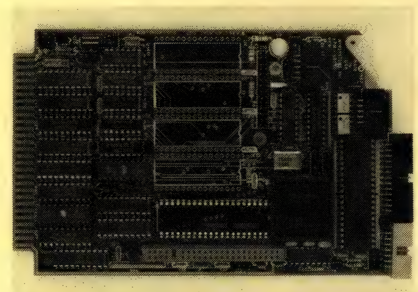

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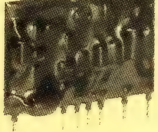

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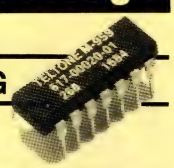

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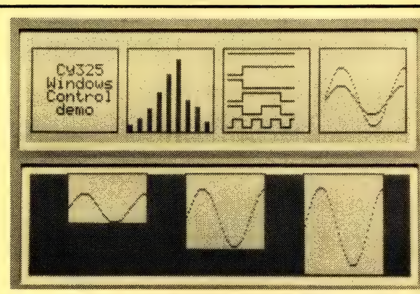

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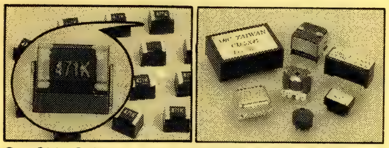

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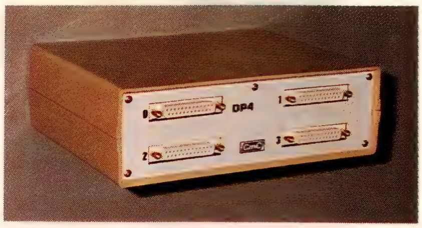

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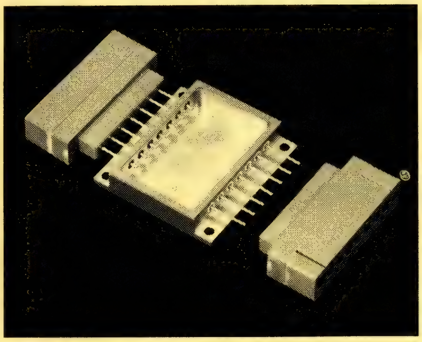

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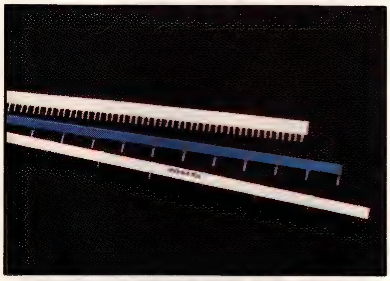

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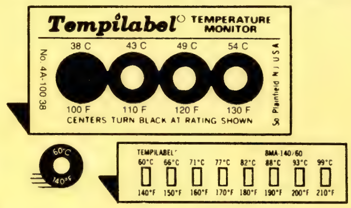

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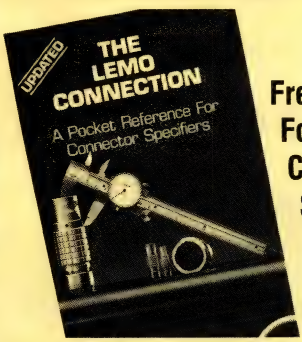

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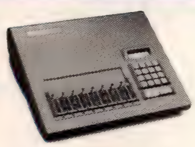

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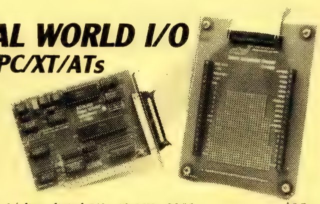

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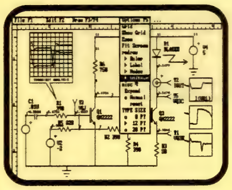

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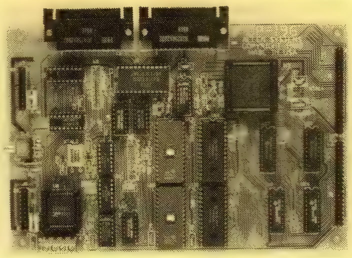

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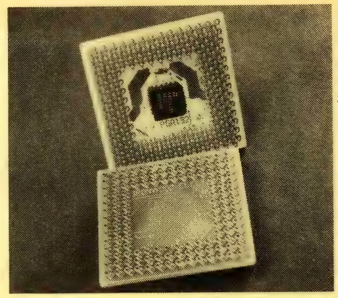

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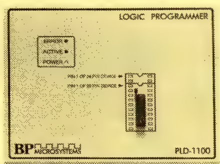

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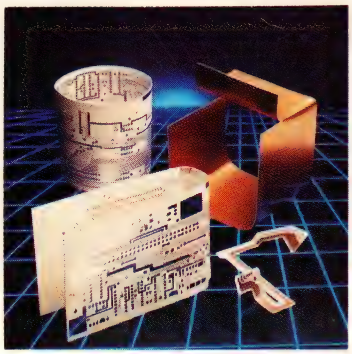

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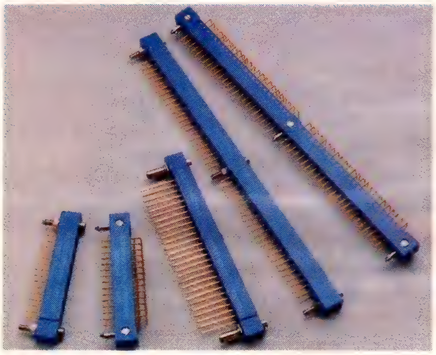

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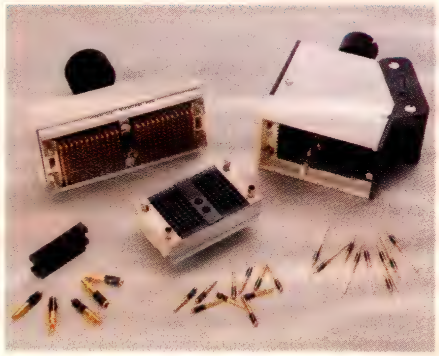

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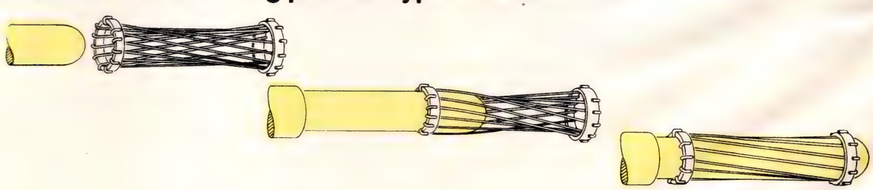

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Apr. 13	Mar. 23	Test & Measurement, Digital ICs	Closing: Mar. 31 Mailing: Apr. 20
Apr. 27	Apr. 6	Communications Technology, Special Issue Communication ICs	Closing: Apr. 13 Mailing: May 4
May 11	Apr. 20	Analog Technology, Special Issue Computer Peripherals	Closing: Apr. 28 Mailing: May 18
May 25	May 4	Digital ICs, Computer Peripherals	Closing: May 25 Mailing: June 15
June 8	May 18	Components, Digital ICs	
June 22	June 1	Semicustom ICs, Computer Boards	Closing: June 9 Mailing: June 29
July 6	June 15	Product Showcase — Volume I, Power Supplies	Closing: June 22 Mailing: July 13
July 20	June 29	Product Showcase — Volume II, Components	Closing: July 21 Mailing: Aug. 10
Aug. 3	July 13	Integrated Circuits, Computer Boards	
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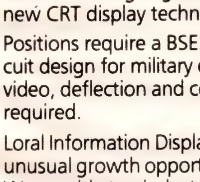

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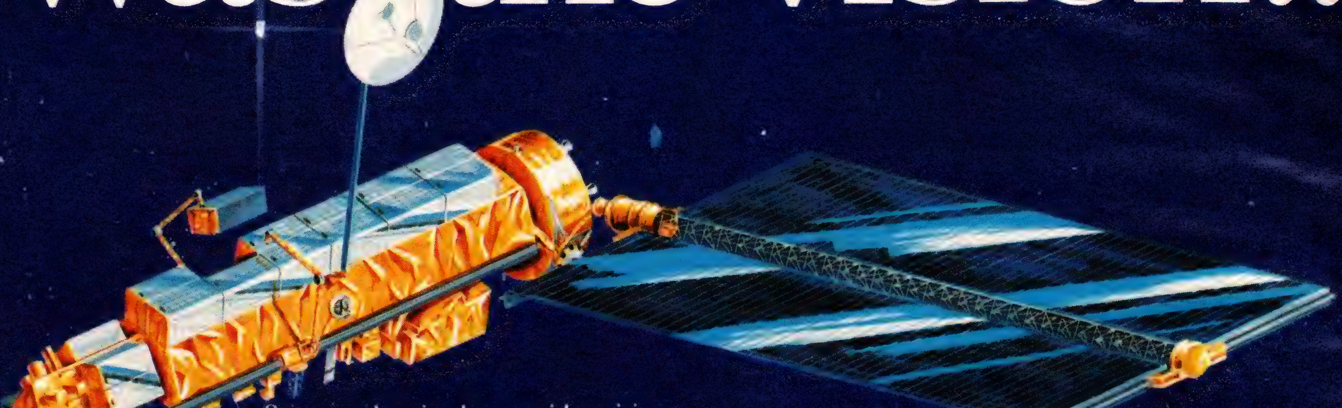

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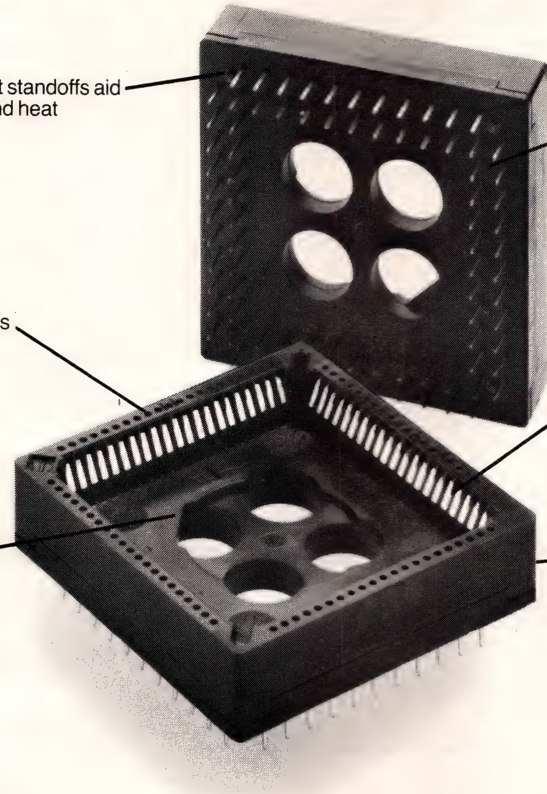

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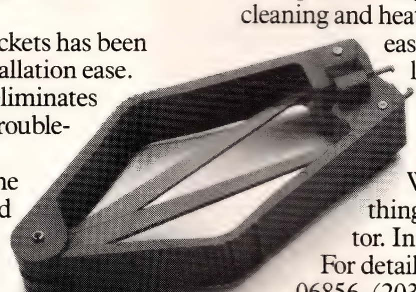

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LOOKING AHEAD

EDITED BY JULIE ANNE SCHOFIELD

Power problems fuel sales of power-conditioning units

Blackouts, brownouts, and voltage swings have become such a problem that micro- and minicomputer owners will be spending almost a billion dollars for protection by 1992, according to a study done by Frost & Sullivan (New York, NY). The study predicts that the $585 million spent in 1987 in this market could total $637 million for 1988 and $918 million annually by 1992.

The electric power for the micro- and minicomputer may be one of the most overlooked factors of computer operation, says the New York company. But power quality is declining in the US. In fact, the North American Electric Reliability Council has reported what most computer users already know—that the frequency and length of outages are increasing.

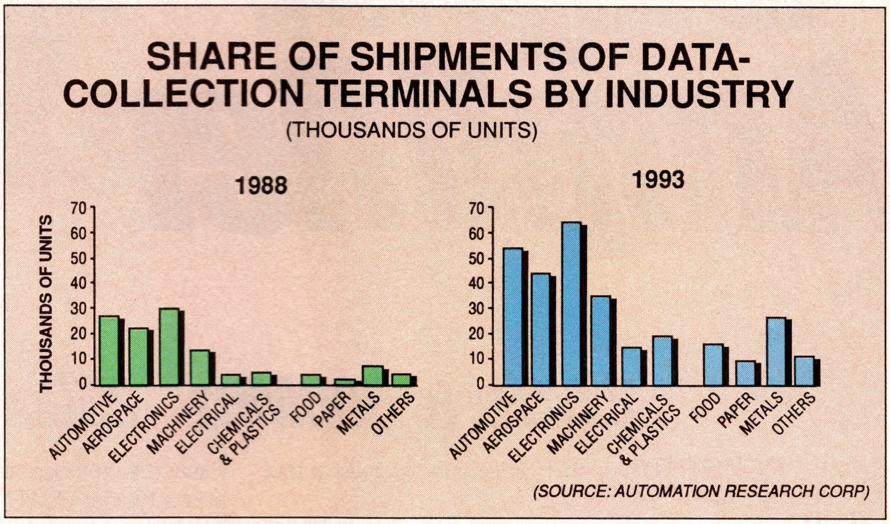
The power-conditioning-equipment market comprises four major categories: surge suppressors and isolation units to protect against voltage spikes; voltage regulators to keep power within a specified range; battery-backup units to provide current during an outage; and power-disturbance monitors. The demand for the first three categories of equipment is rising significantly, reports Frost & Sullivan. The demand for power-disturbance monitors, however, is declining because most computer users assume that power will be a problem and install protective equipment rather than monitoring for a disturbance.

The largest equipment category at present, surge/isolation products, accounted for $204 million in sales in 1987. This figure should increase to $212 million for 1988 and $250 million by 1992. However, the market-research firm predicts that by 1992 battery-backup units will overtake surge/isolation products with $420 million in sales. Battery-backup units represented $200 million in sales in 1987 and could total $232 million for 1988.

The remaining growth-product category, voltage regulation units, represented $146 million in sales in 1987. Frost & Sullivan predicts that this figure will reach $158 million for 1988 and $215 million in 1992.

US manufacturing plants turn to FDC terminals

The US market for factory data-collection (FDC) terminals will increase to nearly 300,000 units in 1993, predicts Automation Research Corp (Medfield, MA). More than 120,000 data-collection terminals were shipped to US factories in 1988. Over 150,000 are expected to be shipped this year—an increase of more than 22% over last year. Overall, shipments of FDC terminals are expected to grow at an average annual rate of nearly 19% during the next five years.



FDC terminals are used in automatic data collection, which is a top priority of most US manufacturers, according to the management-consulting firm. Many existing and emerging technologies are helping users to reduce the amount of handwritten transactions and to increase data accuracy. In fact, the ultimate goal of most progressive users is to have paperless, or less-paper, factories. New system architectures incorporate the latest tools for data distribution and production reporting. These tools include bar codes, magnetic stripes, communications networks, operating systems, and databases. As a result, data-collection systems are important in the implementation of computer-integrated manufacturing at US manufacturing plants.

Automation Research Corp predicts that the largest growth in FDC terminals will be in the paper, food, and chemical industries. Paper companies acquired less than 3000 terminals in 1988, but sales are expected to climb to over 9000 units in 1993. Food companies bought about 5000 terminals in 1988 and are expected to buy over 15,000 in 1993. Most of these terminals will bar-code types. Chemical companies have also started to use bar codes to manage their operations. This industry bought about 6000 FDC terminals in 1988 and is expected to buy 19,000 terminals in 1993.

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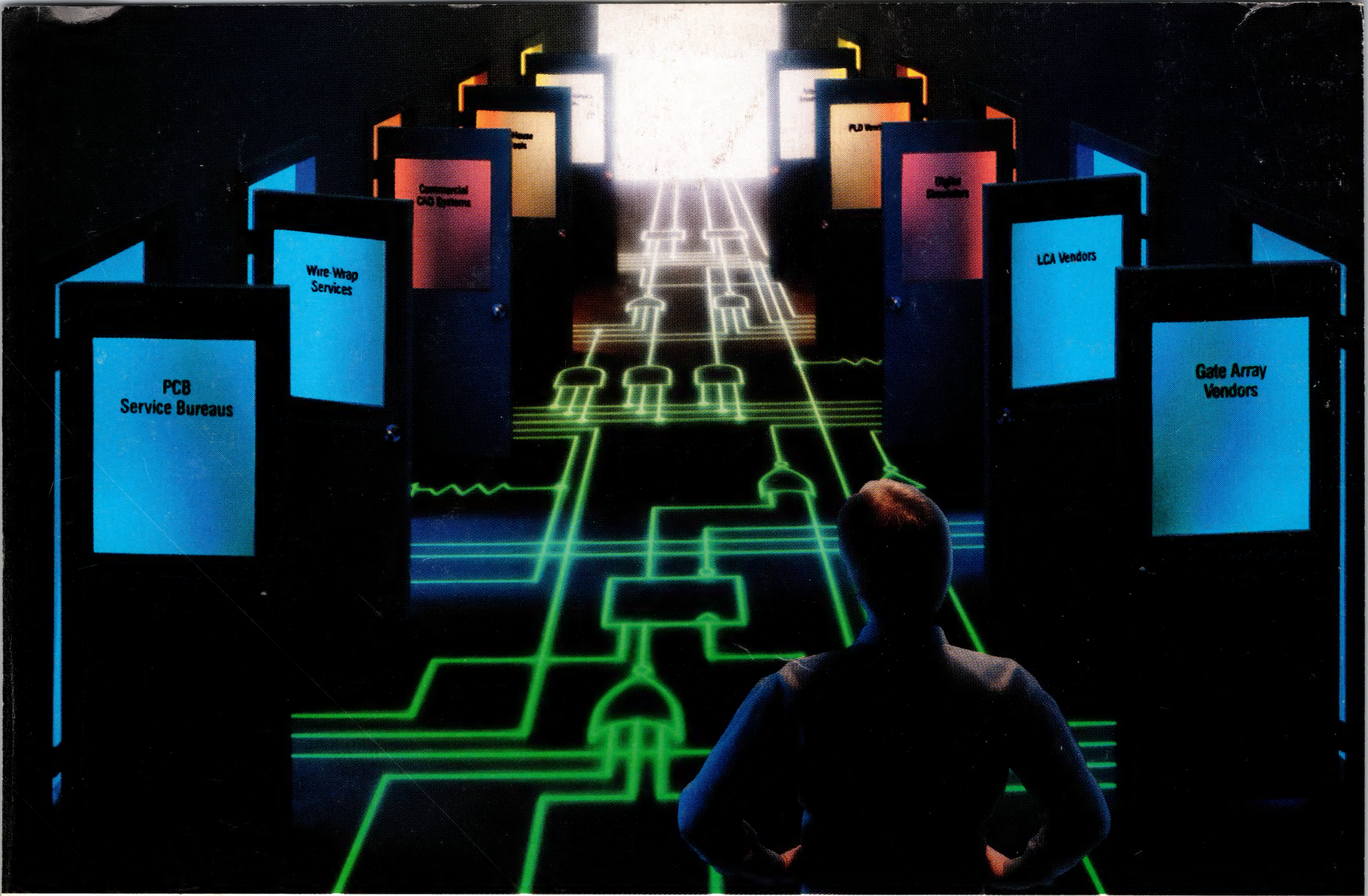

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